

Examining the physiological, cognitive and behavioural correlates of mental toughness.

by

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For my parents:

‘All that I am, or hope to be, I owe to my angel Mother’ - Abraham Lincoln.

‘The older I get, the smarter my father seems to get’ - Tim Russert

ABSTRACT

Mental toughness has received extensive research attention in recent years because of its intuitive and theoretical association with successful performance. However, several significant omissions in understanding remained. This thesis aimed to address these gaps through various research approaches and methodologies, collectively resulting in a biopsychological perspective. The primary objectives were to provide a more holistic perspective of mental toughness and generate quantitative support for the various biological (2D:4D) cognitive-affective (self-structure), physiological (cortisol response) and behavioural (performance) differences that have been associated with the construct. The findings suggested that mental toughness is a multifaceted construct and manifests in several areas of human functioning; specifically, a particular cognitive-affective profile may underlie mental toughness (they possess a positive self-concept and a particular self-structuring style, namely integration). Furthermore, levels of cortisol during a competitive event (a physiological indicator of perceived stress levels) were significantly negatively related to mental toughness, suggesting that mentally tough individuals have a reduced perception of threat in competitive situations (giving support for the notion that they perceive competition or stress as a potential challenge for personal growth and improvement). An objective marker of mental toughness was also supported; specifically, 2D:4D ratio (indicative of prenatal testosterone levels) related significantly with scores on a mental toughness scale, giving support for the biological underpinning of the construct and an objective marker of mental toughness. Finally, two case examples are provided to demonstrate the usability of these important markers (cognitive, biological and physiological) in an applied context.

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Publications

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CHAPTER I: THE QUEST FOR A DEFINITION

‘An athlete is a normal person with the gift of undying passion to be the best and achieve greatness’ - Amanda Ring.

INTRODUCTION

Sport is a global multi-billion pound business and, dating back to the Olympics and beyond, it provides one of the most prevalent arenas for human competition. Individuals and nations strive for marginal, performance enhancing edges over their competitors, in pursuit of the wealth, prestige and pride associated with sporting success. Huge sums are invested in sporting tournaments, with no better example than the London 2012 Olympic Games, costing the nation, at the latest estimate, around £5bn. Therefore, superior performance by British athletes on home soil was crucial, in order to satisfy the many investing bodies and sponsorship companies. Many more billions have been spent on developing the grass roots of sports clubs and local communities, in order to cultivate young talent in the United Kingdom. The investment aims to generate rewards in terms of achievement in 2012 and beyond, in order to demonstrate cost effective outcomes. Indeed, gold medals must be achieved, in order to secure future funding, and athletes are under pressure to fulfill their investment. An understanding of some of the factors which underpin sporting success is therefore increasingly important and examination of research knowledge to this end is necessary.

One important feature of sporting success is the psychological profile of the winning performer. Of course, superior psychological attributes and skill are necessary in a variety of competitive environments, particularly sport (MacNamara, Button, & Collins, 2010; Fletcher, Rumbold, Tester & Coombes, 2011). Considerable empirical evidence supports the notion that relevant psychological attributes contribute to successful sport performance (cf. Cohn,

1990; Crocker & Graham, 1995; Gould, Dieffenbach, & Moffett, 2002; Gould, Greenleaf, Dieffenbach & McCann, 2001; Gould, Guinan, Greenleaf, Medbery & Peterson, 1999; Greenleaf, Gould & Dieffenbach, 2001). Moreover, it appears that the best performers, i.e., those at the highest tier of performance, progress as a consequence of their superior psychological attributes and skills (Deaner & Silva, 2002). At the elite level, the differences between performers in terms of tactics, physiological indices and talent are minimal (Moran, 2004) and hence personality and psychological factors increase in significance. Moreover, research suggests that individuals with adaptive psychological characteristics typically perform more consistently and in line with their potential, than those lacking in such characteristics (Gould et al., 2002). In order to understand the psychological qualities that allow individuals to achieve great success, an empirical (quantitative) and phenomenological (qualitative) examination of salient characteristics in the sporting environment is necessary.

In order to determine the most important psychological attributes that are related to sporting success, Gould et al. (2002) interviewed several high performing coaches, athletes and parents and gathered their perceptions of central psychological variables in elite athletes. The researchers reported that the most commonly reported higher order theme (cited by 73.3% of participants) was “*mental toughness*”. Therefore, the widespread attention that then focused upon mental toughness in both research and practice is less than surprising. Research over the last decade has operationalised mental toughness as a multidimensional construct (it consists of several distinct yet related characteristics, rather than a single psychological entity) and potentially hierarchical (each attribute varies in terms of its importance and the attributes are generally ranked in order of salience) psychological construct (Clough, Earle & Sewell, 2002; Coulter, Mallett & Gucciardi, 2010; Fourie & Potgieter, 2001; Golby & Sheard, 2006; Golby, Sherd & Van Wersch, 2007; Gucciardi, Gordon & Dimmock, 2008;

Jones, Hanton & Connaughton, 2002). Moreover, importantly, mental toughness is thought to be associated with successful performance in competitive environments. Initial anecdotal evidence and qualitative interview accounts have purported an association between mental toughness and performance (Gucciardi et al., 2008; Jones, Hanton & Connaughton, 2007; Thelwell, Such, Weston, Such & Greenlees, 2010). It was primarily this achievement related aspect of mental toughness that has attracted widespread interest from researchers, athletes and coaches over the last two decades. Sports enthusiasts strive to understand what is unique and appealing about mental toughness and how they might cultivate mental toughness in young athletes. However, it should be acknowledged that the association between mental toughness and performance is far from equivocal and might be deemed worthy of further examination. It should also be noted that some disagreement remains regarding the origins or foundations of mental toughness, i.e., whether the construct is grounded in existential stress theory (Clough, et al., 2002) or in the positive psychology paradigm (Sheard, 2008); discrepancies such as this one are discussed in detail later in this chapter.

This widespread interest and the apparent success of athletes possessing mental toughness has generated a surge in research attention, that has attempted to define empirically the positive psychological construct. Indeed, it is useful to understand the psychological qualities that underpin success in competitive arenas, so that sporting professionals can begin to cultivate and encourage the development and maintenance of adaptive psychological characteristics in sports people. Of course, the ultimate aim is to maximize performance and achievement. As has been noted, mental toughness is arguably one such quality that leads to sporting success, and therefore research that examines the composition of the construct and identifies various markers will aid in this quest to cultivate psychological qualities in athletes.

Firstly, a comprehensive and critical account of the extant literature is necessary to understand the current position of research in this area.

1.1. FONS ET ORIGO OF THE CONCEPT OF MENTAL TOUGHNESS

From one perspective, the origins of mental toughness stem from the concept of mental hardiness (Clough, et al., 2002). This arguably stress-buffering construct, is described as a stable disposition that has received extensive empirical attention in competitive or stressful contexts, and has also been deemed important when considering stress-related health outcomes (Kobasa, 1979). Hardy individuals are thought to perceive demanding situations as challenges that are both desirable and controllable (Maddi & Hess, 1992), whereas those limited in hardiness perceive stressors as threatening, uncontrollable and uncomfortable. Individuals with hardy personalities possess three interrelated characteristics: Commitment (i.e., a propensity to involve one self with whatever one is doing), Control (a tendency to feel and act as if one is influential) and Challenge (i.e., a belief that demanding situations are a welcome opportunity for self-development, rather than a threat). The three interrelated, yet distinct attributes, are thought to allow an individual to perceive change or competition as challenging, growth promoting and as opportunities for development. Moreover, because of their psychological makeup, hardy individuals are observed to suffer less incidence of stress related negative consequences, including physical and mental illness (Maddi, 2002) and generally are able to maximise their potential and perform with consistency (Golby & Sheard, 2004). The proposed performance benefits of possessing mental hardiness have been demonstrated in a variety of contexts, including business (Maddi, Kahn & Maddi, 1998) fire fighting (Maddi, Harvey, Resurrection, Giatras & Raganold, 2007) and Rugby League (Golby & Sheard, 2004).

Indeed, stress is a prevalent feature within competitive arenas such as sport. Therefore, psychological constructs that may buffer against the adverse effects of stress are particularly appealing to researchers in this field. The construct of mental toughness has been compared to mental hardiness and they are thought to encompass similar characteristics (Clough et al. 2002). However, these two constructs may be considered conceptually distinct (Clough, et al., 2002) and therefore further qualitative research was necessary to define specifically mental toughness. Clough et al. (2002) aimed to develop a unique conceptualisation of mental toughness that grounded it in the context of stress research and existential theory. This group of researchers found that athletes commonly reported characteristics that were similar to those of hardiness, aside from an additional attribute, termed ‘confidence’ (involves an unshakeable and stable belief in one’s abilities). Possessing a belief in one’s abilities differentiates the hardy and mentally tough individual. In this sense, it appears that mental toughness enables individuals to cope with stress effectively, as does hardiness (Maddi, 2002) yet also allows them to *proactively* seek out opportunities for self-development rather than just *react* to stressful circumstances (as does the hardy individual).

Clough et al.’s (2002) model holds advantages in that it was drawn from a conceptually rigorous construct that has received widespread empirical support and is grounded in sound psychological theory. The 4 C’s model has also received promising empirical support in several contexts, including sport and business environments (Clough, et. al., 2002). These researchers contend that mental toughness is a global construct that can manifest in any area of life, including personal relationships, vocational endeavours and sport. Elsewhere, researchers have adopted a more specific approach, solely focusing upon the sporting domain. They argued that perhaps sport presents a unique collection of stressors and therefore research focused in this context might aid the understanding of key

psychological constructs. Perhaps this approach is a necessary alternative to the more generic perspective, if we are to understand what is unique about success in this particular arena (Crust, 2008). Indeed, sports performers may rank (mental toughness is thought to be hierarchical; Gucciardi, et al., 2008; Crust, 2008) specific characteristics of mental toughness differently (self-belief is the highest ranked variable in many sport studies), in comparison with those working in business environments. Crust (2008) highlighted the potential for subtle differences in mental toughness definition among different sports, particularly in the rating of importance for each characteristic.

Sheard, Golby & Van Wersch (2009) provided one of the first theoretically informed (positive psychological domain) quests to establish a sport specific definition. These researchers corroborated themes and quotations from several previous conceptualisation studies (in essence, a meta-analysis of qualitative research scripts) in order to develop a definition that represented the responses from a large sample of athletes from a wide variety of sports. Two further studies from the same authors established a three factor model of the construct and provided initial support for the corresponding measure's internal consistency and discriminant validity. The resulting instrument, the Sports Mental Toughness Questionnaire, comprises of items that underpin a model that represents the characteristics of mental toughness (i.e., confidence, control, commitment). The authors also demonstrated that initial discriminatory power in that SMTQ scores differed significantly among levels of sporting achievement (international/national/regional standards). Further support for the measure's properties was found by Crust & Swann (2011) although further development and refinement of the measure is necessary. Therefore, this particular measure was deemed appropriate for use in the present research quest. It is important to consider the two different research approaches to understanding mental toughness that have been presented thus far; and

to consider other conceptual models and evaluate their contribution to understanding in this area.

1.2. THE QUEST FOR A DEFINITION

Despite two decades of interest and recognition of the importance of mental toughness, a narrow research focus has arguably restricted adequate progress in understanding. The literature has primarily sought to provide qualitative accounts of the construct (Sheard, 2008) and present rich data, elicited from high performing athletes, coaches and other individuals, such as parents. Aside from Clough et al.'s (2002) cognitive-behavioural analyses in business and educational contexts (their work discriminated among individuals based upon cognitive and behavioural performance) the mental toughness literature was primarily qualitative. Therefore, the existing conceptual models are based upon the responses from limited (in size) samples of athletes. The inherent criticisms of initial conceptualisation studies will be discussed in detail later in this chapter.

The rapidly evolving interest in the construct of mental toughness generated widespread enquiries from researchers in different parts of the world, including Australia (Coulter, et al., 2010; Gucciardi, 2012) America (Gould, Finch & Jackson, 1993b; Jones, et. al., 2002) England (Golby & Sheard, 2004; Nicholls, Polman, Levy & Backhouse, 2008; Golby & Meggs, 2011; Crust, 2008) and South Korea (Chang, Chi & Huang, 2012). Unfortunately, the use of different samples and various theoretical approaches has prevented the possibility of examining cultural differences related to mental toughness. Nevertheless, the quantity of research and international interest illuminates the perceived importance of mental toughness in performance related contexts.

Thus far, as noted, the literature presents several different conceptual models of mental toughness. It is important to address the current conceptual understanding in order to highlight the inherent omissions, and subsequently direct future research in this area. There appears to remain significant confusion in mental toughness understanding and definition because of several factors. One is the nature of reported characteristics, whether that is behavioural or psychological attributes. For example, there are researchers who focus upon what mentally tough sports people actually do, i.e., '*they cope better than their opponents*' (Jones et al., 2002) and those who look at the psychological characteristics of mental toughness, e.g., 'self-confidence, determination'. Alternatively, selected researchers have provided lists of characteristics and hierarchically ordered them (such is the approach of Gucciardi et al., 2008; Jones et al., 2002; Thelwell, Weston & Greenlees, 2005) whereas others propose more holistic definitions, e.g., Gucciardi et al. (2008) state that mental toughness includes various cognitive, behavioural and physiological factors and also provide lists of characteristics that collectively represent 'mental toughness'.

It appears that mental toughness encapsulates varying cognitive, physiological and behavioural factors, which allow an individual to remain in pursuit of their goals, despite external pressures (potentially encouraged and motivated by pressure), and consistently achieve their physical and skill potential (Sheard, 2008). According to this definition, mental toughness manifests itself, or is expressed in, several areas of human functioning. However, research has not adequately examined these specific manifestations of mental toughness. This is a central aim of this thesis.

In order to develop an holistic perspective of mental toughness, examining these possible cognitive, physiological and behavioural indices in larger samples would provide a welcome development in understanding. The addition of research of this nature is particularly

important, as the extant literature is predominantly qualitative (Sheard, 2008). The various behavioural, cognitive and physiological variables that have been implicated to underly mental toughness are presented in Table 1.1. Quotations were taken from several qualitative research studies (Gucciardi et al. 2008; Jones, et. al., 2007; Thelwell, et. al., 2010; Sheard, et. al., 2009).

Table 1.1. Behavioural, cognitive and physiological characteristics of mental toughness

Behavioural	Cognitive	Physiological
‘Mentally tough athletes work and train relentlessly’.	‘They are focused’.	‘They seem to be able to push through their physical pain barriers’
‘They just seem to come back from defeat even stronger and give everything in competition’.	‘They seem to bounce back from poor performances and come back even stronger’.	‘They have a higher tolerance for pain than other athletes’.
‘Mental toughness means performing at your best when the pressure is on’	‘They cope better with stress than their opponents’.	‘They are all round physically tough, in training and competition’.

N.B. The statements provided are drawn from the transcripts of coaches and athletes in a variety of studies. ‘They’ refers to mentally tough sports performers.

1.2.1. Conceptualisation consensus vs. ambiguity

The multiple definitions that were generated through qualitative research adopted varying methodological approaches, protocol and samples. An attempt is made here to attenuate any remaining confusion by drawing upon the similarities among the existing

models of mental toughness (Table 1.2). Moreover, in order to present a balanced perspective, the subtle differences among definitions are also considered.

Table 1.2. Mental toughness characteristics' studies

Jones et al. (2002/2007) attributes	Examples of participants quotes	Clough 4 C's model	Thelwell et al. (2005)	Gucciardi et al. (2008).	Example of participants quotes:	Sheard et al. (2009).	Comparison
Having an unshakeable belief in your ability to achieve your competition goals.	"Mental toughness is about your self-belief and not being shaken from your path".	Confidence.	Holding a complete belief in one's abilities and future achievements.	Self-belief vs. self-doubt.	Self-belief in your mental and physical ability under pressure, and in your ability to persevere and overcome any obstacle and/or challenge that you may face during your [football] career.	Self-belief	
Having an unshakeable self-belief that you possess unique qualities	"He had the self-belief in his ability to know he was making the	Confidence.		An unshakeable, tough attitude directed towards			

and abilities that make you better than opponents.	right decision”			becoming a champion of the game.			
Bouncing back from performance setbacks as a result of increased determination to succeed.	“Nobody’s ride to the top is completely smooth; there are always little hiccups in the road”.			Resilience vs. fragile mind-set.			
Having an unshakeable desire and internalised motives to succeed.	“You’ve got to want to do it, but you’ve got to want to do it for yourself”	Commitment		Self-motivated vs. extrinsically motivated.		Determination.	Many studies include the word “unshakeable” suggesting that mental toughness involves having stable and enduring desires and motives.
Remaining fully	“If you want to	Similar to	Remaining	Concentration		Visualisation	

focused on the task at hand in the face of competition distractions	be the best, you have to be fully focused on what you're doing, there are inevitable distractions".	commitment.	focused	and focus vs. distractible and unfocused.		(the utilisation of psychological skill to maintain focus).	
Regaining psychological control after unexpected, uncontrollable events.	"It is definitely about not getting unsettled by things you didn't expect or can't control".	Control	'remaining calm under pressure and keeping emotions under control'				Clough summarises control as feeling influential in one's life and over life outcomes. However, Jones (2002) split the control aspect into attention/emotional.
Pushing back the boundaries of physical and emotional pain, while still maintaining	"In my sport you have to deal with the physical pain from fatigue, dehydration	Similar to control.		The ability to push oneself to one's physical, mental, and emotional	'To the best of [their] ability whilst carrying an injury....pushing [their] body		The ability to endure pain in the pursuit of success is reported across several studies.

technique and effort under distress in competition and training.	and tiredness. You are depleting your body of so many different things; it's a question of pushing yourself".			limits in pursuit of victory'.	through extreme physical fatigue'.		
Accepting the competition anxiety is inevitable and knowing that you can cope with it.	"I accept that I'm going to get nervous, particularly when the pressure's on, but keeping a lid on it and being in control is crucial".	Challenge	Thriving under pressure and in competitive situations. Always cope better with stress than opponents.	Handling pressure vs. panicky mind-set.		Positive cognition.	Coping appropriately with pressure and thriving on pressure-filled environments is reported across all studies.
Thriving on the pressure of	"If you are going to	Challenge	'Reacting to situations	Handling pressure vs.		Positive cognition.	

competition	achieve anything worthwhile, there is bound to be pressure”		positively and approaching challenges’.	panicky mind-set.			
Not being adversely affected by others’ good and bad performances.	“The mentally tough performer uses others’ good performances as a spur”.	Confidence/Challenge.		Tough attitude vs. weak attitude.			
Remaining fully focused in the face of personal life distractions.	“Once you’re in the competition, you cannot let your mind wander to other things”	Control					Both definitions suggest that controlling one’s thoughts and directing them appropriately is important.
Switching a sport focus on and off as required.				Sport Intelligence (high-low SI).			Having an intelligent approach towards training and competition is

							presented in several definitions
				Emotional Intelligence vs. Emotionally immature.			Gucciardi et al. (2008) were the first to note emotional intelligence as an important factor.
			creating an “aura”	creating an “aura”			Thelwell et al. (2005) was the only study to report an “aura” that other athletes could feed off.

A commonly reported definition emerged from a qualitative study by Jones, et al. (2002). The author's definition suggests that mental toughness is:

'having the natural or developed psychological edge that enables you to 1) generally, cope better than your opponents with the many demands (competition, training, lifestyle) that sport places on a performer; and 2) specifically, be more consistent and better than your opponents in remaining determined, focused, confident, and in control under pressure. (p. 209).

This definition reflects effective coping strategies (which is congruent with Clough et al.'s 4 C's model, as it is grounded in existential stress research), self-confidence (cited as the primary attribute) consistency, determination, focus and perceived control.

Jones et al. (2002)'s definition is limited in some ways, e.g., a) it compares the abilities of a mentally tough individual with other less tough athletes "*cope better than your opponents*" yet their study made no comparisons with less tough athletes, nor provided opposite pole terminology, i.e., described what it means to lack mental toughness, and b) for describing what mentally tough athletes do (behavioural characteristics), rather than the psychological features of mental toughness.

Table 1.1. illustrates the similarities among different mental toughness definitions. For example, all definitional studies report "*self-belief*" as the primary and most important attribute (the construct is thought to be structured hierarchically; Gucciardi, 2012) of mental toughness (Bull, Shambrook, James & Brooks, 2005; Clough et al., 2002; Gucciardi et al., 2008; Thelwell, et. al., 2005). Bull, et., al. (2005) included a sample of cricketers in their study and the characteristics were analogous to those described by eight Olympic champions,

three coaches and four sport psychologists in Jones', et al., (2002/2007) two studies. Global themes in all studies included an unshakeable belief in one's abilities (Jones, et al., 2007), self-belief (Bull, et al., 2005), holding a complete belief in one's abilities and future achievements (Thelwell, et al., 2005) and self-belief (Gucciardi et al., 2008), and this attribute was reported as the most important by all participants. Competitive anxiety was considered an important factor, e.g., mentally tough performers were seen to be able to cope with pressure (Thelwell, et al., 2005; Sheard, 2008), deal with pressure and anxiety, (Bull, et al., 2005) thrive on pressure and accept the presence of competitive anxiety (Jones, et al., 2007; Gucciardi, et al., 2008). The only variation lies in whether researchers theorise that mental toughness allows individuals to accept and deal with anxiety (more reactive, e.g., Jones et al., 2007) or actually seek out and thrive in anxiety eliciting situations (more proactive, e.g., Gucciardi, et al., 2008; Sheard, et al., 2009).

The second most important attribute that appears consistent across all conceptual studies is that of motivation: mental toughness includes a desire and motivation to achieve (Bull, et al., 2005), demonstrating focus and commitment (Thelwell, et al. 2005), being self-motivated (Gucciardi, et al., 2008) and possessing internalised motives to succeed, or motivation and focus (Jones, et al., 2002/2007). Jones, et al. (2007) and Bull, et al. (2005) also reported similar specific attributes that exemplified the global themes. For example, Bull, et al. (2005) reported attributes such as overcoming self-doubt, focusing on improving weakness, feeding off physical conditioning, keeping perspective, good decision making, and honest self-appraisal, that appear conceptually similar to Jones, et al.'s (2007) reported characteristics of remaining fully focused, regaining psychological control, not being adversely affected by others' performances, and accepting competition anxiety. Moreover, Sheard, et al. (2007) reported characteristics such as 'maintaining positive cognition before

and during performances' which indicates a level of perceived control over one's emotions and an ability to perceive challenges as opportunities. These authors also highlighted the importance of self-belief in one's abilities and an undying determination and motivation to succeed. Such characteristics hold similarities with many other proposed definitions, such as those provided by Clough, et al. (2002), Jones, et al. (2007) and Bull, et al. (2005).

There are also similarities between Clough, et al., (2002) 4 C's model and Jones' (2007) working definitions. Jones, et al. (2007) reported attributes of mental toughness, including awareness and control of thoughts and feelings and staying focused (analogous to control) utilising long-term goals as a source of motivation (comparable to commitment), pushing to the limit and accepting challenges (similar to challenge) and having an unshakeable belief in one's abilities (similar to confidence). Such similarities increase the validity of these characteristics, as similar attributes have been reported across different cultures and sports. Therefore, despite the endless list of characteristics that have been generated by qualitative studies, which may have added to the conceptual confusion (Crust, 2008) it appears that similar core attributes emerge which adds further weighting to the proposed definitions.

Adding further credibility to these models of mental toughness, Thelwell, et al. (2010) interviewed ten high performing gymnasts about their understanding of the construct. Participants reported similar characteristics to those provided in Clough (2002), Bull, et al. (2005), Jones, et al. (2007) and Sheard, et al. (2007) including holding a complete belief in one's abilities and future achievements, reacting to situations positively and approaching challenges (analogous to challenge; Clough, et al., 2002), remaining calm under pressure and keeping emotions under control (similar to facilitative anxiety or control), remaining focused (similar to commitment), thriving under pressure and in competitive situations (similar to

seeking out challenges). Although several subtle differences are evident across studies, e.g., Thelwell, et al. (2005) were the first to report the characteristic of creating an “*aura*”, suggesting that other athletes were able to “*feed off*” the confidence and positivity of mentally tough individuals. It is the first study to consider the social manifestation of mental toughness, i.e., the influence of those with mental toughness upon team mates. However, an “*aura*” is arguably a subjective feeling that cannot be accurately described as an actual psychological attribute and therefore may be difficult to measure. The limited sample size of ten also detracts from confident generalisation of these results, as with other qualitative studies attempting to conceptualise mental toughness.

Bull and colleagues (2005) concluded that the similarities found between theirs and Jones and colleagues’ (2002) study suggest trustworthiness for the purported mental toughness attributes. However, slight differences among definitions may be confusing on one hand, yet provide a further insight into the potential subtle differences, across a variety of sports. For example, Bull, et al. (2005) reported an attribute termed “*competitiveness with self*” as well as others, which is congruent with Jones, et al.’s (2002) definition of mental toughness, but not specifically mentioned in their list of characteristics.

One important criticism of these mental toughness models is that the proposed definitions appear to be overly inclusive, in that they appear to describe all aspects of an athlete’s experience in relation to success, yet fail to determine what is unique and special about mental toughness (Crust, 2007). What has now become the “*elusive phenomenon*” (Caddick & Ryall, 2012) requires further examination, in order to continue progress in understanding this salient construct. Moreover, it is important to note is that the data from many conceptual studies were taken from the retrospective accounts of parents and coaches; the internal validity of such statements is limited because of the diffusion of accurate recall

over time (Robinson-Riegler, 2012) and the potential for a positive social response bias (Furnham, 1986). Further questions of validity arise when considering the coaches' and parents' invested perceptions, because of their own involvement and desire for their athlete to succeed. Demonstrably, further research is necessary to provide quantitative support for the characteristics proposed by qualitative studies. Table 1.3. presents the theoretical and epistemological approaches of each individual mental toughness study, to provide further clarity. In doing so, this thesis aims to highlight the similarities among different studies and the emerging definitional consensus.

Table 1.3. Mental toughness definition studies: a comparison

Researchers	Semi-structured questions	Theoretical approach	Participants and selection criteria.	Aims	Inductive/deductive approach.
Clough et al. (2002)	None	Existential stress research (mental hardness).	Several successful sports performers.	To provide a theoretical framework of mental toughness.	Deductive (productive of the MTQ48).
Sheard et. al. (2009)	None. Quotations were gathered from several mental toughness studies.	Positive Psychology.	N/A.	To develop a sport specific definition and measure of mental toughness.	Deductive (production of the SMTQ).
Jones et al. (2002/2007).	a) Define mental toughness. b) Identify and describe their perception of the attributes of a mentally tough performer.	Exploratory in nature and not guided by a particular theoretical framework.	10 International sports people from varying sports. 8 Olympic champions, 3 coaches and 4 sport psychologists.	To elicit a definition of mental toughness from elite performers. To triangulate results from three different groups of individuals.	Inductive.

Thelwell et al. (2005/2010)	a) What is mental toughness?	Exploratory in nature and not guided by a particular theoretical framework.	Six professional football players. 10 elite gymnasts.	To establish a football specific conceptualisation of mental toughness.	Inductive.
Bull et al. (2005)	a) What is mental toughness? b) How is it developed?	Exploratory in nature and not guided by a particular theoretical framework.	10 England's most "mentally tough" cricketers.	To determine what mental toughness actually is and how it may develop in English cricketers.	Inductive.
Gucciardi et al. (2008).	See Table 3.	Kelly's (1995) personal construct theory framework.	11 Australian football coaches (third party perspective).	To outline a model of mental toughness.	Inductive. Deductive .
Coulter, et. al., (2010)	a) Key characteristics and their contrasts, situations demanding	Kelly's (1995) personal construct	6 Australian cricket players, 5 parents and 4 coaches.	To provide a framework for mental toughness	Inductive.

	<p>mental toughness.</p> <p>b) The behaviours displayed and cognitions employed by mentally tough soccer players.</p>	<p>theory framework.</p>		<p>in Australian football.</p> <p>To triangulate results from three different groups of individuals.</p>	
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1.2.2. Sample selection criteria

Following close inspection of the studies' aims and participant selection criteria, some of the apparent confusion and variation across definitions is fathomable. For example, Jones, et al. (2002) selected Olympic champions as participants. The performance component of mental toughness means that selecting participants for their sporting success is tempting, as sport psychologists are primarily interested in achievement and enhancing the psychological skills and talents of our athletes. Since many had reported mental toughness as central to sporting success, researchers focus upon the "super-elite" of the sporting world. However, are the Olympic champion participants necessarily the most mentally tough athletes? Their success is clearly dependent on several other factors, such as their talent, physical abilities and training (Weinberg & Gould, 2007) rather than their psychological attributes alone. Furthermore, there was no evidence that these performers had achieved their success because of their increased mental toughness. Perhaps the selection of sports people, who are recognised primarily for their mentally tough approach to training and competition, would be more appropriate participants. Such was the approach taken by Bull, et al. (2005). These researchers claimed to have selected the "most mentally tough English cricketers" to include in their research. However, the success of these cricketers was assumed to indicate superior psychological abilities, including increased mental toughness. Moreover, the selection of these 'mentally tough' performers was decided by untrained individuals (coaches and other helpers) who provided anecdotal evidence and subjective insights to support their selections. This method of sample selection is common and obviously limited.

Thelwell, et al. (2005, 2010) selected both professional soccer players and elite gymnasts to provide qualitative accounts of mental toughness (in two separate definition studies). As mentioned, the selection of sports people from one end of the performance

spectrum (the ‘super elite’ and ‘elite’) is limiting at an early stage in research. These researchers took a similar approach to Bull, et al. (2005) in that they emphasised the possibility of inter-sport variation, in terms of the manifestation of mental toughness (Crust, 2008). Although the approach may be more subtle, in that it addresses small variations across different sports, it might limit the utility of that construct definition to soccer/gymnastics alone. It also appears premature to assume that differences exist across different sports, given the early stage in research and the similarities among studies such as Jones, et al. (2002) and Bull, et al. (2005), which suggest that such variation is minimal. Moreover, researchers elsewhere argue that mental toughness applies to many contexts and is a global construct (Clough & Strycharczyk, 2012).

Although research has tended to select successful sports people, as mental toughness usually relates to some level of success, such an approach is limiting, as those who achieve their potential (that is not necessarily excellence) through increased levels of mental toughness, would also be useful in terms of research participants. Research should be careful not to capture sporting success in their analysis of psychological characteristics of champions, but rather pinpoint those who possess the highest mental toughness, that then allows them to achieve their physical and technical potential, at any level of sport.

1.2.3. Theoretical approach

A noteworthy criticism of early qualitative mental toughness research is the atheoretical nature of the studies (Crust, 2007). Although open ended, exploratory research is useful to indicate possible characteristics of mental toughness, repeatable and structured research with a clear theoretical grounding is impossible, when personality theory is neglected (Gucciardi & Gordon, 2008). This lack of theoretical underpinning initially confused rather than enriched understanding (Connaughton, Wadey, Hanton & Jones, 2008).

However, more recent attempts to conceptualise mental toughness provide some clarity, utilise scientific theory and demonstrate rigorous procedures and techniques of data analysis. A recent, qualitative investigation by Gucciardi et., al., (2008), assessed Australian soccer players' perceptions of mental toughness, guided by Kelly's (1991) personal construct theory framework. The framework presumes that individuals are actively engaged in creating meaning in their lives, i.e., they synthesise previous knowledge and anticipate future predictions about their behaviour and experiences by actively perceiving and interpreting their environments. Personal construct theory includes a fundamental postulate and eleven subsequent corollaries, which shed light upon the specific development, maintenance and modification of personal constructs (psychological attributes) (Walker & Winter, 2007).

An alternative and necessary approach to understanding mental toughness and its theoretical position and relation to other constructs is to examine its correlates. In doing so, researchers can understand the conceptual space within which mental toughness belongs.

MENTAL TOUGHNESS CORRELATES

Optimism

Optimism may be one of the primary predictors of sporting success (Norlander & Archer, 2002) and is a stable disposition relating to positive perceptions of one's future (Burke, Joyner, Czech, & Wilson, 2000). Nicholls, et al., (2008) found that optimism shares a significant positive relationship with mental toughness, and in particular, adaptive coping strategies. Specifically the greater individuals' mental toughness, the more likely they are to have an optimistic disposition. Such a finding is supportive of qualitative understanding, suggesting that mentally tough individuals have positive perceptions of their future, a perception of control over their lives and an unshakeable belief in their own ability; taken together, such qualities would logically lead to expecting success and positive outcomes in

their futures. Nicholls, et al., (2008) recommended the inclusion of optimism training in mental toughness interventions, although such a claim requires further support. The authors utilised a heterogeneous sample of sports and therefore conclusions could be generalised widely across sport in general, yet detailed and specific understanding of variations in mental toughness across sport is impossible. Also, this research was cross-sectional in nature and therefore causal inferences cannot be drawn.

Goal orientations

Utilising 40 competitive Wushu athletes in Malaysia, the PPI and TEOSQ were used to determine the athletes' goal orientation preferences and mental toughness levels. Hierarchical cluster analysis revealed three distinct profiles of goal orientations: a) high task and moderate ego; b) moderate task and low ego and c) moderate task and moderate ego. Further analysis revealed that those with high task and moderate ego goal orientations scored significantly higher in terms of negative energy control than those with moderate task and low ego orientations. Also, those with high task and moderate ego goal orientations reported greater positive energy control than those with moderate task and ego orientations. The authors reported no significant differences among athletes with different goal orientations/profiles on several performance outcomes. But, when comparing medalists and non-medalists, those who gained medals reported significantly higher levels of self-confidence and negative energy control than non-medalists. Such a finding suggests that mental toughness relates to successful performance; the use of a performance measure rather than noting the achievement level of athletes is a welcome addition to research in this area. Previous research predominantly utilised cross-sectional designs that report the current achievement standard of participants, i.e., international, national level, etc. Although such evidence is necessary and exploratory, causal inferences are impossible, i.e., it is unknown

whether mental toughness increases as a function of achievement, or if increased mental toughness results in higher performance, or an interaction of the two.

While the study presents a novel understanding of mental toughness and directs researchers towards the important consideration of goal profiles, once again, the study's limited sample size detracts from confident generalisations. Furthermore, only Malaysian athletes were included and potential cultural differences were ignored. The measurements utilised in this study, particularly the PPI, have been subject to recent criticism, because of a questionable factorial structure and inadequate internal consistency (Gucciardi, 2012) and therefore the results need to be taken as exploratory in nature and useful in directing future research to examine these important variables. However, the results make sense theoretically, in that previous qualitative research has suggested that mental toughness is characteristic of those with relentless desires for success and 'natural competitive edge', which suggests that those with mental toughness would be both task and ego goal orientated.

However, other researchers have chosen to draw from and build upon other theoretically grounded and similar constructs, like the approach adopted by Clough, et al. (2002). As previously noted, the 4 C's model of mental toughness sees the construct as firmly grounded in the context of stress research. Clough, et al.'s (2001) model has received initial support as its corresponding measure (MTQ48) demonstrates adequate psychometric properties (Crust, 2009) and has been shown to discriminate among individuals in terms of performance on various physical tasks, i.e., pain tolerance activity, and in terms of cognitive coping style (Crust & Clough, 2005; Nicholls, et. al., 2008). Other earlier investigations (Jones, et al., 2002; Bull, et al., 2005; Thelwell, et al., 2005) appeared to take an inductive approach to understanding of mental toughness and therefore had relatively little theoretical input in terms of personality theory.

MENTAL TOUGHNESS: A STRESS BUFFER

The more recent stress-performance models have eluded to the potential for individual differences in terms of their optimum stress levels (4) Individualized Zones of Optimal Functioning (IZOF). Hanin (1980, 1986 and 1995) proposed that each athlete has a peak performance state of optimal anxiety. This theory suggests that the optimal level of state anxiety differs from individual to individual and does not always exist on the midpoint of the continuum. Moreover, the optimal level of state anxiety is considered to be a bandwidth rather than a single point. With regard to the individual differences issues, this has real relevance in the field of applied sport psychology. If this optimum level of anxiety (stress level) can be determined, it is then possible to manipulate it, using psychological strategies. However, methodological difficulties in measuring pre-performance anxiety have limited the conclusions of many studies in this area. Nevertheless, there is some initial support for Hanin's model, from a number of studies which have shown that predictions of performance based on the IZOF theory have been more accurate than other models (e. g., Turner & Raglin, 1996).

This model, along with other recent models (e.g., Flow theory) recognises the importance of individual differences in the stress process, rather than attempting to outline a 'stimulus response' model, which suggests the individual is a passive respondent to the situation and responds in a uniform manner to given stressors. More recent models of stress consider the individual to be at the centre of the process, by engaging in an active interaction with the situation (see Lazarus, 1991). With this shift in understanding in mind, it is not surprising that a primary aim within this field has been the identification of potential individual differences, which can moderate the stress process. Many psychological factors

have been found to relate to stress response variability, including high trait anxiety (Taylor, Reis, Sausen, Padilla, Markham, Potterat & Drummond, 2008). Trait anxiety is a personality factor that predisposes an individual to view certain situations as more or less anxiety provoking (Spielberger, 1983). Typically, research has shown that individuals with high trait anxiety will perceive events as being more threatening than individuals with lower trait anxiety.

2.3.1. Mental toughness and coping

Several definitions suggest that mental toughness may be related to coping better with the demands of sport, and therefore a brief introduction to the coping literature is provided, followed by more specific research that relates to mental toughness.

Coping has been defined as:

“a constantly changing cognitive and behavioural effort to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person” (Lazarus & Folkman, 1984, p. 141).

Coping responses can be categorised into three ‘higher order’ functions: problem focused coping, emotion focused coping and avoidance coping (Lazarus & Folkman, 1984). Problem focused coping encompasses strategies aimed at reducing distress by directly eliminating or tackling the stressor. Emotion focused coping describes strategies directed towards regulation of emotional arousal. Lastly, avoidance coping alludes to the behavioural and psychological efforts to disengage from and avoid a stressful situation. Aspects of personality are thought to contextualise the appraisal of stressors, in that they influence each stage of the stress and coping process. Hence, it is assumed that personality traits can directly

influence coping, by restricting or assisting the selection and use of specific strategies, i.e., if an individual has high mental toughness, they may be more likely to appraise stressors and their resources, in such a way that problem focused coping strategies are regularly selected and utilised. A secondary influence arises when considering the intensity of stressors experienced and the perceived effectiveness of selected strategies. Those high in mental toughness may perceive stressors with lower stress intensity and perceive their selected coping style to be the most efficacious in removing potentially negative consequences (Bolger & Zuckerman, 1995). Several research studies have begun to address such propositions; a brief outline of knowledge in this area is presented in Table 2.1.

Table 2.1. Mental toughness and stress

Authors	Study aims	Findings	Limitations	Overall contribution to knowledge
Clough, et. al. (2002).	Assess the effect of feedback upon performance in those with high and low mental toughness (external stressor).	Those with highest levels of mental toughness performed similarly across all conditions. Those low in mental toughness performed better following positive feedback and worse following negative feedback.	Lacks ecological validity.	Mentally tough individuals appear to be less sensitive to feedback.
Nicholls, et. al. (2008)	Assess the association between mental toughness and coping style.	Mental toughness was significantly associated with more approach coping styles and less avoidance coping strategies.	Cross-section design, limits subtle understanding. Predominantly male sample.	Mental toughness relates to coping, i.e., tough individuals typically use a particularly style of coping (approach and emotion focused).

Kaisler, Polman & Nicholls. (2009)	Deepen understanding of mental toughness and coping.	<p>Mental toughness was associated with:</p> <ul style="list-style-type: none"> • More approach and emotion coping strategies. • Less avoidance strategies. • Lower levels of stress intensity. • Higher levels of perceived control. • <p>No association between the actual perceived stressors.</p>	Cross sectional design and a lack of consideration of the changes in coping, despite it being a dynamic and changeable process. The authors did not consider baseline stress intensity levels which could also influence the explored relationships.	Mental toughness relates to perceived control over stressors, coping style and perceived levels of stress intensity.
Crust (2009)	Determine the relationship between affect intensity and mental toughness.	No significant association between mental toughness aspects and affect intensity.	Self-report measures – difficult to recall stressful events afterwards.	Suggests that the way in which performers cope with stress is more important in mental toughness research than actual affect intensity.
Crust and Clough (2005)	Explore the association between pain threshold and mental toughness.	A positive relationship between pain threshold (laboratory task) and mental toughness was identified.	Lacks ecological validity (laboratory cold water task).	Provides quantitative support for the notion that mentally tough performers are better able to push pain barriers.

Jones et al. (2001) proposed that mentally tough athletes were '*better*' at coping with demanding circumstances than their opponents. However, as previously noted, such a claim is problematic, given that researchers have made no comparisons with less mentally tough athletes. Also, the claim that effective coping is an important facet of mental toughness was reported by a small selection of athletes (N=12) and therefore confident generalisation would be premature at this stage of research. Despite the limitations associated with the evidence for this claim, it seems theoretically probable that mentally tough athletes are better at coping with demanding circumstances than those with lower levels of the construct. But, it is clear that the descriptive nature of qualitative mental toughness research has not allowed this proposition to be tested satisfactorily.

Mental toughness can be viewed as conceptually similar to mental hardiness (stress buffering personality disposition) and therefore the importance of mental toughness when considering stress is feasible. Khoshaba & Maddi (1999) found that hardy individuals generally utilise more approach focused coping strategies. Mentally tough individuals are able to appraise the competitive environment in such a way that allows them to excel in pressure filled situations, perceive obstacles as challenges rather than threats, rebound from setbacks quickly and generally cope with the demands placed upon them with decreased levels of stress and negative affect (Gucciardi, et al., 2008; Jones, et al., 2007; Thelwell, et al., 2005).

Previous research has shown that aspects of personality, such as neuroticism, mediate the influence of interpersonal stressors and alter an individual's stress appraisal and degree of negative affect (Suls & Martin, 2005). Therefore, it is logical to suppose that mental toughness could be an important construct in the context of stress. For example, the aspect of control over one's emotions is particularly important when considering the effects of stress.

Clough, et al., (2002) assessed the degree of emotional control ability of participants to negative or positive feedback, following a cognitive planning task. Those participants who scored higher on the measure of mental toughness (MTQ48) performed consistently following both positive and negative feedback. In other words, the feedback appeared to have little effect upon their performance, whereas, positive feedback improved the performance of those lacking in mental toughness and negative feedback had a detrimental effect. Therefore, Clough, et al., (2002) provide support for the proposition that those with mental toughness are “*insensitive*” to criticism (are “*stubborn minded*” (Bull, et al., 2005) and possess greater emotional stability. This study presents a novel line of experimental research, in that it assesses individuals whilst performing an experimental task in controlled settings. Indeed, more valid results are generated from studies such as this one. However, it should be noted that the ecological validity of these findings was limited and the experimental task was incomparable to a real life competitive stressor. Although performance differences have been identified in relation to mental toughness, little is known about the exact cognitive mechanisms underlying this difference in performance. Researchers then began to address specific areas of cognition, in order to shed light upon the ability of mentally tough individuals to remain unperturbed by competitive stress and negative feedback.

Nicholls, et al., (2008) utilised a cross sectional design in order to explore the association between stress, coping and mental toughness in a sample of 677 athletes, who were predominantly male (n=454). The authors identified the significance of coping when considering mental toughness. Results supported theoretical propositions that ‘mental toughness is related to effective coping’, in that the construct was positively associated with approach coping style, i.e., generating solutions and engaging in practical strategies to effectively resolve stressors (such as mental imagery, effort expenditure, logical analysis and

thought control) and negatively associated with avoidance coping strategies, i.e., avoiding consideration of the stressor or denying the severity of the problem (subscales of distancing, resignation and mental distraction). According to Nicholls, et al.,'s (2008) findings, it seems therefore that mentally tough individuals have a rational and realistic approach to stressors; they plan practical solutions and overcome barriers, rather than rely upon emotional outlet and support (emotion focused) or conscious attempts to avoid the problem (avoidance focused). However, mentally tough individuals were also found to utilise emotion focused coping strategies, which are typically characteristic of individuals who perform less well. It appears that the exact coping mechanisms employed by mentally tough individuals, in relation to the nature of stressors, remains relatively unclear. Therefore, further research that addresses the study's claims with different samples of sport performers is necessary.

The data support the notion that mental toughness and coping are distinct, yet related concepts, as the variables are not perfectly correlated (low to moderate correlations between each mental toughness characteristic and aspects of coping were found). However, the data were drawn from a cross sectional study and therefore the results might be a remarkable coincidence, and similar research addressing the association between mental toughness and coping was necessary (associations between coping, other priori hypothesised positive psychological attributes and mental toughness were considered in Study 1).

Although the study prompted exploration of the correlates of mental toughness and provided empirical support for the relevance of coping skills, the predominantly male sample detracted from confidently generalising this understanding to females. Furthermore, the performance levels of athletes (international/regional etc.) were not reported, and differences across these tiers of performance were not considered. While these kinds of cross sectional

studies may provide exploratory trends, more longitudinal studies would be useful, to identify the stability of coping strategies in relation to mental toughness.

Kaiseler, Polman & Nicholls (2008) also extended research in this area by taking more detailed measurements of the type and appraisal of competitive stressors in a large sample of sport performers. Another important variable highlighted by these authors was the perceived effectiveness of specific strategies, i.e., whether mentally tough individuals view certain coping mechanisms as more successful than others. Therefore, Kaisler, et al., (2008) sought to explore the appraisal of stressors and coping strategies in a heterogeneous sample, including a mixed gender sample of performers at various standards, ranging from international competition to club level participation.

The authors aimed to highlight the potential importance of stressor type, interpretation or perception of stressors, utilising different coping strategies and perceived control over stressors. The study utilised the MTQ48 and confirmed low to moderate positive correlations between subscales of mental toughness and several problem focused strategies. Furthermore, negative associations were identified between mental toughness and emotion/avoidance focused coping styles. The findings from this study suggest that coping is a changeable and context specific process that is dependent largely upon situational variables (Bolger & Zuckerman, 1995) and therefore mental toughness is not wholly accountable for differences in coping.

Nevertheless, quantitative support was provided for the assumption that mental toughness may be important in mediating the stress response, and is therefore a salient construct when considering performance in competitive and stressful situations. However, the selection of a single stressor and cross sectional design provides a simplistic perspective of coping and stress. Stressors are ever changing and intermittent, therefore a longitudinal study

that assesses intra individual differences in stress perceptions or coping strategy selections might aid in understanding the influence of mental toughness on different stressors, and their interactive effect upon coping selection or effectiveness. Further to this, accurate recall for up to fourteen days after a specific stressor was a limitation of Kaisler, et al.,'s (2008) study. Perhaps a constant diary record may provide a more internally valid method of data collection.

Kaisler, et al., (2008) also found that mentally tough individuals reported lower levels of stress intensity. Such tough individuals self-selected specific and different stressors and perceived higher levels of control in comparison with those with lower mental toughness. The actual specific stressor type had no association with mental toughness, which therefore suggests that mentally tough individuals do not perceive particular stressors in the competitive environment that are different from those with lower levels of the construct. The adaptive ability of mentally tough individuals may lie in their use of more effective problem focused coping strategies, their perception of increased control over stressors, and appropriate selection of effective coping strategies. A further finding to note was that emotional control was related to lower stress intensity, whereas interpersonal confidence was associated with higher levels of stress. This particular aspect of the MTQ48 has received some criticism, as mental toughness has been conceptually associated with achievement, rather than a focus upon interpersonal relationships.

Perhaps research in the sporting arena may wish to refocus attention upon competitive confidence and achievement related perceptions, rather than broadening the construct to general areas of life. Arguably, mental toughness relates to the ability to direct behaviour, emotions and cognitions towards achievement, and overcoming barriers, rather than socialising.

A notable limitation of the Kaisler, et al., (2008) study was that the authors did not consider the initial variation in baseline stress intensity (therefore it was impossible to identify or calculate the difference in intensity between usual/everyday stress levels and the selected stressful event). Moreover, the heterogeneous sample allows for widespread generalisation, but detracts from detailed understanding. Nevertheless, Kaisler, et al., (2008) provide initial quantitative support for the conceptualisation provided by Clough, et al., (2002) who suggest that perceptions of control and decreased stress intensity are characteristics of individuals with increased mental toughness.

1.3. CURRENT CONCEPTUAL UNDERSTANDING AND DISCERNING THE FUTURE

1.3.1. A summary of mental toughness characteristics

The primary characteristics of mental toughness reported in the extant literature include:

- **Positive self-concept, confidence, self-belief and self-esteem** (e.g. Bull, et al., 2005; Cashmore, 2002; Fourie & Potgieter, 2001; Gucciardi, 2012; Jones, et al., 2002; Loehr, 1982; Thelwell, et al., 2010; Sheard, 2008).
- **Ability to cope with pressure, stress and adversity** (e.g., Clough, et al., 2002; Fourie & Potgieter, 2001; Gould, et al., 1987; Gucciardi, et al., 2008; Jones, et al., 2002).
- **Seeking out challenges and opportunities for self-improvement and thriving under pressure** (Clough, et al., 2001; Gucciardi & Gordon, 2008).
- **Courage and motivation to achieve** (Bull, et al., 1996; Gucciardi, 2012; Thelwell, et al., 2010; Sheard, 2008).
- **Maintaining consistency and demonstrating persistence to achieve long-term goals** (e.g. Clough, et al., 2002; Fourie & Potgieter, 2001; Gould, et al., 1987; Gucciardi & Gordon, 2008; Loehr, 1982; Thelwell, et al., 2004).

- **Resilience** to criticism and poor performances (e.g. Clough, et al., 2002; Gucciardi & Gordon, 2008; Loehr, 1982; Thelwell, et al., 2004).

At an exploratory stage in research it would be limiting to select a specific definition produced by any one team of researchers. All proposed definitions have several advantages and potential criticisms in terms of their theoretical approach and sample selection.

Therefore, the current thesis takes an eclectic approach, using several conceptual models (as discussed earlier) and selects the most salient (ranked the highest in importance by sports performers) and widely reported characteristics of mental toughness. Table 1.4. presents the model of mental toughness that underpins Study II (Chapter IV), followed by a more detailed and critical discussion of each separate characteristic. This approach was selected since current models of mental toughness (those that have been generated by individual teams of researchers) require further substantiation. Therefore, whilst measurement development and refinement is an important goal for research into mental toughness, and hence the earlier studies presented in this thesis utilised existing measures of mental toughness (i.e., SMTQ and PPI-A), the studies that aimed to identify the subtle associations between mental toughness and physiological indices included well established and credible measures, to assess the central characteristics of mental toughness.

It is therefore important to present the selected characteristics and highlight the widespread reporting of this attribute, followed by a brief summary of the research that has examined that particular psychological characteristic. Table 1.4 presents the most commonly cited characteristics by existing studies into mental toughness.

Table 1.4. Mental toughness conceptualisation

Mental toughness characteristic	Examples of studies that report this characteristic
Self confidence	Bull et al. (2005); Jones et al. (2002/2007); Gucciardi et al. (2008)
Competitive anxiety	Clough et al. (2002); Fourie & Potgieter (2001); Gould et al. (1987); Jones et al. (2002); Gucciardi & Gordon (2008).
Motivation	(Bull et al. (1996); Thelwell et al. (2010).
Determination and persistency	Clough et al. (2002); Fourie & Potgieter (2001); Gucciardi & Gordon. (2008).
Resilience	Clough et al. (2002); Gucciardi & Gordon (2008); Thelwell et al. (2004).

1.3.2.1. Self confidence

Confidence, self-belief and self-esteem (e.g. Bull et al., 1996; Cashmore, 2002; Connaughton, et al, 2010; Crust, 2008; Favret & Benzel, 1997; Fourie & Potgieter, 2001; Gould et al., 1987; Gucciardi & Gordon, 2008; Jones et al., 2002; Loehr, 1982; Sheard, 2008; Thelwell et al., 2004) are included in many definitions of mental toughness.

Self-confidence is defined as the belief that one can successfully execute a specific activity, rather than a global trait that accounts for overall performance optimism. Vealey [87, p. 222] defines "*sport confidence*" as "*the belief or degree of certainty individuals possess about their ability to be successful in sport.*" Self-concept represents a composite view of oneself that is developed through evaluative experiences and social interactions. As Bandura (1997) has noted, however, a global self-concept will not predict the intra individual variability in performance as well as self-confidence perceptions that vary across activities and circumstances. "*Self-esteem*" is another concept related to self-confidence and refers to an individual's personal judgement of their own worthiness. Although the two may be related, certain individuals do not have high self-confidence for a given activity, but nevertheless still

"like themselves"; by contrast, there are those who may regard themselves as highly competent at a given activity, but do not have corresponding feelings of self-worth.

The related concept of self-efficacy is defined as an individual's beliefs in one's capabilities to organise and execute the courses of action required to produce given attainments (Bandura, 1997). In the sporting context self-efficacy may relate to an athlete's belief in their ability to execute a particular skill effectively and therefore win a game or match (Bandura, 1997). A meta-analysis provides clear evidence for a significant and reciprocal relationship between this construct and performance (Moritz, Feltz, Fahrback & Mack, 2000). A conceptually related construct that holds importance in the sporting arena is that of competitive anxiety.

1.3.2.2. Competitive anxiety

Thriving on the pressure of competition and perceiving potential challenges as opportunities for self-improvement (Clough, et al., 2002; Gucciardi, et al., 2008; Thelwell, et al., 2005; Sheard, 2008) rather than possible threats to the self (characterised by a negative interpretation of anxiety) is a central characteristic of mental toughness. Mentally tough individuals are able to accept the presence of stress in the competitive environment, remain positive despite external burdens, cope with sport and competition with decreased levels of stress and anxiety and thrive under pressure (Clough, et al., 2002; Gucciardi, et al., 2008).

An inherent aspect of competitive sport is the need for players to meet the demands of competition and to perform well under pressure (Moritz, Feltz, Fahrback, & Mack, 2000).

“The perception of a substantial imbalance between environmental demand and response capabilities under conditions which are a failure to meet demands is perceived as having important consequences will respond to increase levels of cognitive and somatic state

anxiety” (Martens, Burton, Vealey, Bump & Smith, 1990, p.10). Previous research (Russell & Cox, 2000) highlights the importance of competitive anxiety in distinguishing successful and unsuccessful athletic performance.

1.3.3.3. Motivation

Having an insatiable desire and internalised motivation to succeed (Jones, et al., 2007; Sheard, 2008) and an ability to bounce back from performance setbacks with an increased motivation and determination to succeed, are included in many accounts of mental toughness.

Deci and Ryan’s (1985) Self-determination Theory of Motivation and Intention is one theory that attempts to explain individuals’ motivations and reasons for sport participation. The Self Determination Theory has received much attention and support in the literature on sport and exercise behaviour (Ryan & Deci, 2001). It suggests that individuals can vary in their motives to take part in a sport, specifically that they vary in the degree to which they are self-determined, i.e., whether their sports are fully integrated into the individuals’ self. Ryan & Deci (2000) propose that three types of motivation lie upon a continuum: intrinsic, extrinsic motivations and a-motivation. Intrinsic motivation pertains to behaviours that are carried out because of the pleasure and satisfaction one derives from personal achievement or acquisition of skills. The self-determined motivation sub themes include identified regulation (perceived as personally useful and worthwhile) and integrated regulation (the sport is viewed as important and coherent with other aspects of the self).

In contrast, extrinsic motivation refers to perceiving the activity as a means to achieve something other than personal reward, for example, external regulation (engaging in behaviour because of environmental constraints), introjected regulation (internal pressure to perform the activity due to a perceived association with one’s self-worth). Finally, a-

motivation refers to a complete disinterest and diminished motivation, or lack of perceived association between effort and outcomes within a given sport.

Self-determined or autonomous forms of motivation (intrinsic) are distinguished from controlling types of motivation (guilt, others' perceptions). Cognitive evaluation sub theory highlights the potential environment or contextual variations that may enhance or thwart self-determined motivation. The Organismic Integration sub theory outlines the processes of internalisation of behaviours that are performed originally for non-self-determined and controlling factors, and then integrated into individuals' self and performed autonomously. For example, an athlete may take up rugby in order to satisfy a parent. However, after time immersed in the activity, the athlete begins to view their rugby career as an integral part of their self, they gain esteem, make friends, etc. The activity has now become an internalised, more autonomous process. Finally, the importance of innate psychological needs (e.g., competence) in considering motivation is incorporated in the psychological needs sub theory. There are other important features which have been advanced to help understand the concept under examination. Selected researchers have argued that the theory artificially categorises and separates different forms of motivation (i.e., introjected/intrinsic) which is oversimplifying complex and overlapping motives, where many drives and motives are important. However, the model has received widespread attention in sport and has been linked with performance across a range of sports, ages and contexts (Jöesaar, Hein & Hagger, 2012).

1.3.3.4. Determination/persistency/consistency/GRIT

Determination has been included in many accounts of mental toughness (Bull, et al., 1996; Cashmore, 2002; Clough, et al., 2002; Fourie & Potgieter, 2001; Jones, et al., 2002; Loehr, 1982; Thelwell, et al., 2004), and also elements pertaining to persisting with long term

goals (Sheard, 2008), producing consistent performances (Sheard, 2008) and striving to achieve goals which require great investment and effort (Crust, 2008). Determination is grounded in the theoretical framework of a concept termed “Grit”. Grit is defined as a perseverance and passion for long term goals (Duckworth, Peterson, Matthews & Kelly, 2007) and entails working strenuously toward challenges, maintaining effort and interest over years, despite failure, adversity or plateaus in progress. The gritty individual approaches achievement as a long term challenge, hence demonstrating great stamina and persistence. Where disappointment or boredom leads to loss of effort or lack of pursuing the goal, the gritty individual maintains motivation and relentlessly strives to achieve goals. The concept of Grit is also theoretically and experimentally associated with performance in academia (Duckworth, et al., 2007).

1.3.3.5. Resilience

Many accounts of mental toughness include an ability to bounce back from performance setbacks with increased determination to succeed, an insensitivity to failures or negative feedback (Bull, et al., 2005), a resilience or refusal to “give in” or accept defeat (Jones, et al., 2002/2007) and a resilience to changes in the environment (Crust & Keegan, 2010).

The construct of psychological resilience can be defined as “*the effective coping and adaptation although faced with loss, hardship or adversity*” (Ahanghar, 2010). Resilience has been associated with a variety of behavioural and psychological outcomes, i.e., relaxation skills, optimism or coping strategies, such as humour to distract oneself from negative cognitions. Folkman & Moskowitz (2000) reviewed literature that suggests positive emotions buffer against stress and support the “*broaden-and-build theory of positive emotions*” (Fredrickson, 2001).

The “*broaden-and-build theory of positive emotions*” (Fredrickson, 2001), stipulates that negative emotions (sense of threat) narrow one’s thought action repertoire. Other resources are devoted to preparation for action, i.e., fight or flight response. Positive emotions are proposed to have the opposite effect, i.e., expand the range of possible cognitions and behaviours. Therefore if one becomes more resilient, one is able to elicit more positive emotions and thus increase the variation of strategies one possesses to deal with adversity. The theory has also been supported by physiological data. Positive emotions may have contributed to participants’ accelerated cardiovascular recovery, following exposure to negative emotional stimuli (Tugade, Fredrickson & Bennett, 2004). Moreover, increased resilience has been shown to predict perceived ability in a sample of tennis players (Sheldon & Eccles, 2005). Furthermore, Rugby League players playing at international level have been found to have significantly higher levels of resilience (and general mental toughness) than those playing at a national level (Golby & Sheard, 2004).

1.4. SUMMARY OF MENTAL TOUGHNESS RESEARCH AND LIMITATIONS

1.4.1. Mental toughness and context

Selected researchers have suggested that mental toughness appears to be context specific (Crust, 2009), i.e., individuals who demonstrate and experience increased mental toughness in the sporting arena, may be less mentally tough in a situation that requires lengthy mental effort (perhaps in an educational context). Although mental toughness appears to have a degree of generalisability, e.g., Clough's et al.'s (2002) research has demonstrated that mental toughness relates to educational and business settings; it appears that intra-individual variability in mental toughness, according to the context of focus, is possible. There still remains debate as to whether mental toughness is a composition of trait-like attributes or a situation dependent entity.

Perhaps researchers should draw from the individual and environmental interaction approach. The Environmental Psychology movement acknowledges the relationship that exists between an individual and his/her environment. It assumes that knowledge of either the individual or the environment is insufficient, and that research should attempt to understand the interactive combination of the individual's characteristics and aspects of the environment. Hence, the study of individuals in more authentic contexts is crucial to achieve a valid and comprehensive understanding of any psychological construct (Study I explores the construct in a real life setting).

If mental toughness is a psychological entity, it could be a composition of specific characteristics that allow an individual to enter into competitive environments and thrive

under pressure, that are independent of the situational variables (trait-like). Those specific mental toughness attributes then interact with the environment and produce many manifestations of the construct. Therefore further research may attempt to identify the stable and enduring characteristics of the mentally tough performer and then begin to address their interaction with situational variables. Thelwell, et al. (2010) conducted a sport-specific investigation into the development of mental toughness. They reported that the 10 American (n=5) and British (n=5) gymnasts recognised that their responses to barriers and life events in sport and other contexts (education) were instrumental in developing their mental toughness. Therefore, it appears that mental toughness might manifest and develop from many areas of an individual's life and transferable coping strategies and skills are beneficial in several arenas. The gymnasts recognised that their responses to both positive and negative events across different situations and contexts were important to their development of mental toughness. Therefore, if future research is to acknowledge such a proposition, it might seek to consider mental toughness manifestation across several situations and contexts and broaden their consideration of development variables, rather than restricting examination of the construct to sport related achievements or adversity alone.

1.4.2. Mental toughness: proactive or reactive

Gucciardi, et al. (2008) also highlighted a similar problem with current research into mental toughness. These researchers suggest that defining the construct solely in the context of adversity and stress (as does Clough, et al.'s 2001 model) is somewhat limiting, as the construct also appears to include enabling characteristics that help performance when life is going positively. However, Clough, et al. (2001) imply that mental toughness allows individuals to react efficiently to stress and have greater coping abilities. It is therefore somewhat surprising that research has examined the positive outcomes (achievement related)

associated with mental toughness, rather than also exploring mentally tough individuals' responses in times of adversity (Coulter, et al., 2010). Further studies are necessary to examine the manifestation of mental toughness in positive and negative circumstances.

Both research teams, i.e., Clough, et al. (2002) and Gucciardi, et al. (2008) have made welcome contributions in this area, in that it is important to understand the entire range of the construct, from the negative pole (arguably associated with negative life outcomes) to the positive spectrum (related to positive outcomes). Combining both approaches was only recently considered in the conceptualisation model proposed by Gucciardi, et al. (2008) but was not explicitly examined and proposed. To date, the existing research has focused upon the positive aspects of mental toughness, i.e., the positive attributes such as self-belief. Gucciardi, et al. (2008) are the only researchers to provide an opposite pole of high mental toughness in their definition, an approach purported by the personal construct theory framework (Kelly, 1991). Coulter, et al. (2010) utilised a similar guide to explore mental toughness in Australian cricket and present a definition that included the full range of each individual attribute, i.e., they present a high versus low mental toughness model. Furthermore, they consider that mentally tough individuals display abilities in times of adversity (resilience and self-belief) when the going gets tough (period of injury or poor performance), rather than taking the limited focus upon positive performance qualities such as consistent success.

1.4.3. Mental toughness: an elitist ideal?

Researchers outside of sport have begun to view the study of mental toughness as an “elitist” idealism (Caddick & Ryall, 2012). The “extraordinary” success purported to be achieved by mentally tough athletes and their elite and superior psychological attributes, imply perfectionism beyond average human capabilities. The romantic and ideological

perception of the construct has resulted in reporting of “super-human” attributes that are unachievable by the average individual. In many definitions, words such as “unshakeable” motives and self-belief, an “insatiable” desire to achieve, create the image of a romanticised sporting hero, which is deemed unachievable to the “average” athlete. Surely this approach is problematic, given the drawbacks of ideologist terms and entities, that are exclusive to the sporting elite, and therefore of little use to individuals involved in sport at all levels. Given that the “super-elite” are a relatively small group of people, the current research has only addressed the upper spectrum of mental toughness (levels of mental toughness are likely to lie on a continuum from high to low, rather than exist in discrete categories).

Indeed, using an inductive approach that is restricted to a small sub-group is a rather contradictory method. Inductive research typically seeks to unearth the perceptions of a population (sports people). Then the credibility of conceptual models is confirmed by consensual agreement among different participants, in terms of their articulation of mental toughness. Therefore, drawing these verbal accounts from a demographically similar group of individuals is less likely to capture the construct in its entirety.

Also, the epistemological problems of viewing an individual’s achievements in hindsight and determining their psychological abilities according to the outcome should be noted. Attaining a particular level is not necessarily always an indicator of superior psychological qualities. It is important to note that the current perception of mental toughness is very much dependent upon the related outcome; the mentally tough individual is aware of their own emotions, physical abilities and strengths, and they possess a realistic image of their capabilities.

Mental toughness is thought to be a unique psychological construct that relates to effective coping with stress and the demands of competition, rather than merely a success

related psychological entity. As mentioned, the danger of such an approach is the broad reporting of many different positive characteristics, rather than pinpointing a unique definition of what we perceive as “mental toughness”. Exploring a psychological construct solely in a specific elite sub-group of individuals provides a limited perspective. Researchers have done little to examine the various manifestations and compositions of mental toughness across an eclectic group of individuals.

Therefore, this thesis attempts to understand mental toughness and various correlates in performers across various achievement levels (from elite to recreational). It is also important to note that mental toughness measurements are primarily self report measures. However, mental toughness has been said to manifest in several ways, in terms of physiological and cognitive-affective functioning. Therefore, it is important to address these physiological and cognitive-affective variables in order to develop important markers of mental toughness in sport performers.

2.3.4. The physiological correlates of mental toughness

Physical and physiological factors have also been included in definitions of mental toughness (Gucciardi, 2012; Sheard, 2008). Moreover, Crust and Clough (2005) empirically supported the association between mental toughness and pain threshold; specifically those with increased levels of the construct demonstrated a higher pain threshold. These researchers found that individuals scoring highly in the subscales of confidence and challenge were more likely to tolerate a physical endurance task for longer than the lower scoring individuals. Elsewhere, Levy, et al., (2009) used the MTQ48 to demonstrate an association between threat appraisals, a greater ability to cope with pain, and more frequent attendance to clinic based physical therapy sessions, among athletes involved in a sport injury rehabilitation programme. Although such research provides empirical support for the relationship between

commitments to an injury programme, the authors failed to consider the efficacy of the intervention and the athletes' adherence to the prescribed techniques. Mere physical attendance appears a rather crude measure of commitment, as engagement with the prescribed rehabilitation programme was not examined; moreover, there was no consideration of the underlying processes of psychological change during the injury period, with relation to the construct of mental toughness. Nevertheless, the direct and indirect physical correlates of mental toughness have received little attention to date and therefore the study identified a salient area for future research.

As previously noted, mental toughness has received much attention in the context of stress, and therefore, one potential line of research is to consider differences in physiological responses to stress and their link with mental toughness. Previous researchers have drawn the parallel between the mental and physiological toughness literature. The physiological toughness model proposed by Dienstbier (1989) can shed some light upon this apparent theoretical parallel. Dienstbier (1989) has produced several studies that have highlighted the process through which animals achieve physiological toughness. He found that animals, when presented with specific stressors, demonstrated a particular pattern of central and peripheral physiological changes, e.g., heart rate and blood pressure increases and higher concentrations of cortisol and adrenaline. He defined stress in a similar manner to Lazarus (2006) in that he described stressors as situations which an individual appraises as threatening or harmful, and that are perceived to outweigh the organism's coping resources. In line with the more recent challenge and threat research (Jones, Meijen, McCarthy & Sheffield, 2009), Dienstbier (1989) suggested that individuals can perceive such situations as challenges (experience positive adaptations) or threats (experience negative consequences). Moreover, given adequate recovery time (perceived cessation of the stressor) exposure to stressors

results in a ‘toughening’ process, through which an individual becomes more resilient to stress. When examining the mental toughness literature, it appears that several researchers have theorised mental toughness as a construct that incorporates both seeking out challenges in their lives, and appraising those situations as potential opportunities for improvement, i.e., as a challenge. It should be noted that Dienstbier’s (1989) model was based upon research carried out with animals and can therefore be deemed a reductionist conceptualisation. Nevertheless, recent research provides support for claims that individuals who perceive stress as a positive experience (facilitative interpretations of anxiety) tend to secrete lower anticipatory levels of cortisol prior to sporting competitions (Filaire, Ferrand & Verger, 2009). Mental toughness is yet to be examined in relation to such peripheral and central physiological changes in response to stress. Therefore, Study II aims to explore the physiological responses (cortisol secretion) of sport performers and their relationship with mental toughness and performance. This kind of research will significantly advance our understanding of the physiological manifestation of mental toughness and provide objective and quantitative support for the proposition that physiological aspects are important in relation to this construct (Gucciardi, et. al., 2008).

2.3.5. Cognitive-affective correlates of mental toughness

Aside from physiological variables, cognitive and affective characteristics are also thought to contribute to the superior profile of the mentally tough athlete. As previously discussed, the cognitive coping process has been examined and shown to relate to mental toughness. Several definitions of the construct also include the cognitive aspect of a positive self-concept (Bull, et al., 2005; Thelwell, et al., 2007; Sheard, 2008) and high, stable self-esteem (Jones, et al., 2002). However, little is known about the specific cognitive processes

that are related to mental toughness, and whether differences exist among individuals with high or low levels of mental toughness. Study III draws from research on a model of self-structure, which is described in detail in Chapter V (Showers, 2002) that has been shown to discriminate among individuals with high and low self-esteem and a range of other psychological correlates (e.g., mood). In doing so, the study will assess specific cognitive differences that relate to mental toughness: the self-structure of sports people across the entire mental toughness and achievement spectrum (from low level performers to elite level sport people). This research is particularly important to improve our knowledge of specific cognitive variables that are important in understanding the manifestation of mental toughness. Moreover, with further research, cognitive psychological interventions could be implemented with supporting research evidence. This is particularly important if researchers are to

- a) Establish the changeability of mental toughness and
- b) Examine the effectiveness of psychological skills in increasing mental toughness in sport performers.

The current conceptual understanding and knowledge of the construct's correlates allow researchers to examine the effectiveness of particular psychological skill training designs that may increase these correlates. This kind of research is particularly valuable in an applied context, i.e., it might potentially provide practical advice for both coaches and sport psychologists in terms of appropriate skill training.

2.5. OVERALL AIMS AND STATEMENT OF PURPOSE

In summary, widespread attention from researchers around the world has led to the generation of many characteristics, a conceptual consensus is evident, researchers agree the construct is both multidimensional and hierarchical and is related to effectively dealing with adversity or stress and is likely to allow individuals to perform consistently and in line with their potential (Gucciardi, et al., 2008; Jones, et al., 2002; Thelwell, et al., 2005/2010). Research has also identified important associations between mental toughness and related psychological variables, in order to place the construct in an appropriate psychological framework. Researchers can establish construct validity by locating correlations between the measured construct and a number of other measures that should, theoretically, be associated with it (convergent validity) or vary independently of it, i.e., discriminant validity (Westen & Rosenthal, 2003). The primary aim of construct validation is to embed a construct in a nomological network (appropriate psychological knowledge framework) and therefore establish its relationship with other variables, with which it should, theoretically, be associated positively, negatively, or not at all (Cronbach & Meehi, 1955). Although initial research has begun to address this issue, further research that utilises more sophisticated models and measurements (rather than merely self-report measures) is necessary.

This thesis therefore aimed to provide an holistic perspective of mental toughness in sport, specifically to examine its *psychological, cognitive, physiological* and *behavioural* correlates. This is a particularly important addition to the mental toughness literature, as it is currently predominantly qualitative in nature (Sheard, 2008) and this research will advance understanding of this important construct. Placing mental toughness in an appropriate nomonological network and extending the evidence for or against the use of specific mental toughness measures will be achieved. It also undertakes an interdisciplinary approach and

utilises several different methodologies, to increase the validity of findings, and demonstrate that the results are not merely an artifact of a particular research approach or methodology. In order to achieve this overall aim, several objectives are presented.

- 1) Explore the biological underpinning of the construct by examining the association between prenatal testosterone (previously shown to be important in sporting aptitude and performance; Manning, 2002), mental toughness and indications of *behavioural* differences in terms of competitive achievement (Study I).
- 2) Identify key positive psychological correlates in order to place mental toughness in a nomological network and therefore explore the construct and discriminant validity of the SMTQ and PPI-A; this is primarily assessed in Studies I and IV.
- 3) Explore the relationship between *physiological* indices and mental toughness in an ecologically valid environment, in order to develop alternative objective markers of the construct and strengthen understanding of important psychophysiological differences (Study II).
- 4) Identify *cognitive* variations in relation to mental toughness, utilising an evaluative self-structure model (Study IV) in order to understand *cognitive-affective* differences' association.
- 5) Demonstrate the usability of the proposed markers of mental toughness (established in Study I, II, III and IV) in an applied context (Study V).

These objectives were designed to collectively result in an holistic examination of mental toughness. Using varying methodologies (qualitative and quantitative) with both large cohort designs and single case studies ensures that mental toughness is studied from a range of perspectives. The subsequent conclusions could highlight several important directions for future research and begin to provide empirical evidence for the qualitatively generated

claims, i.e., mental toughness is a positive psychological variable (Sheard & Golby, 2006) and it incorporates physiological, cognitive and affective factors (Gucciardi, et al., 2008). This definition suggests that mental toughness can be examined via the biopsychosocial model approach, i.e., the construct incorporates many physiological, cognitive and affective factors, and develops as a result of biological (Horsbrugh, et al., 2008) and social influences (Bull, et al., 2005). The first study presented in this thesis aimed to examine the utility of an objective, prenatal marker of success in sport and perhaps levels of mental toughness. This study was designed to address a significant gap in the extant literature, as only a limited number of research studies have examined the biological influence upon mental toughness development (Crust, 2007). The study therefore explored the effect of prenatal hormone exposure upon this important construct.

CHAPTER II: EXPLORING THE ORGANISATIONAL EFFECT OF PRENATAL TESTOSTERONE UPON THE SPORTING BRAIN

‘Evolution is the greatest engine for intelligent human design’, Charles Darwin.

3.1. ABSTRACT

The 2D:4D ratio, a putative marker for prenatal testosterone, has the potential to explain differences in sport performance. To date there has been little research into the association between sporting performance, digit ratio and psychological variables such as mental toughness. Such research could aid in identifying important predetermined, biological influences upon psychological constructs thought to be salient in the sporting arena. This study examined the relationship between 2D:4D and mental toughness, optimism, goal orientations, aggression, coping style and their association with sport achievement level. A post facto design was adopted. Participants consisted of an opportunity sample of 122 sports people: male (n = 60) and female (n = 62) from a university in North East England and a range of sporting achievement levels (from leisure to international competitive standard) in order to capture the full range of the selected psychological constructs. Following ethical approval and informed consent, digit ratio hand scans were measured, using a Vernier Caliper (both right and left digits). Questionnaires were then completed which were designed to assess the relevant psychological characteristics: PPI-A (Golby, et al., 2007), SMTQ (Sheard, et al., 2009), LOT-R (Scheier, Carver & Bridges, 1994), Buss-Perry Aggression (Buss & Perry, 1992) and 30 item Coping Style Questionnaire (Joseph, Williams & Yule, 1992). MANOVA revealed significant gender differences in digit ratio. Furthermore, 2D:4D was found to differentiate mental toughness scores ($p < 0.001$) and varying levels of sporting performance, which substantiates previous research findings (Manning, 2002). An

interpretation could include the cautious proposal that high prenatal levels of testosterone may contribute to the development of increased mental toughness, optimism, ego/task goal orientations in individuals, and hence aptitude towards sport. Findings provide support for the tentative claim that mental toughness may be partially biologically predetermined.

Theoretical and practical implications are considered, along with limitations of the current study.

3.2. INTRODUCTION

As previously noted, success in sport is determined by marginal psycho-physiological differences. In the pursuit of excellence, adaptive psychological variables are increasingly recognised as important prerequisites to sporting success (Fletcher & Wagstaff, 2009).

Early work on the biological basis of behaviour has identified the organisational effects of prenatal testosterone on various adult psycho-physiological parameters (Neave, Laing, Fink & Manning, 2003). A putative marker for exposure to prenatal testosterone is the 2D:4D ratio (Honekopp, Manning & Muller, 2006). Testosterone influences the growth of the ring finger (4D), whereas oestrogen exposure stimulates the growth of the index finger (2D) (Manning, 2002). The ratio of the index finger to the ring finger (2D:4D) has been shown to be a sexually dimorphic trait. Specifically, males demonstrate a lower ratio, due to increased prenatal testosterone exposure (Manning, 2002). It is suggested that high levels of prenatal testosterone may have a permanent masculinising effect on human behaviour (Manning, 2002) which could explain the relationship between sporting performance and 2D:4D (Honekopp, et al., 2006).

“Masculine” attributes arguably play an important role in sport performance, e.g., aggression. Performance in several sports is negatively related to 2D:4D; these include:

football, athletics, skiing, cross country running and general fitness (Manning, 2002; Honekopp, et al., 2006). Many variations of performance assessment have been used, e.g., actual achievement level, performance across a season, number of successful actions in a match, and similar results are demonstrated. Most recently, Bennett, Manning, Cook & Kilduff (2010) demonstrated the association between elite rugby players' performance and 2D:4D. Those performers with low ratios had a significantly greater number of international selections and number of tries scored. However, the study had a limited sample size of 44 players and therefore confident generalisation of results is problematic. A further study of limited size (n=46) located a significant association between right hand 2D:4D and performance in surfers (Kilduff, Cook & Manning, 2011). The performance was established through the ranking of several expert coaches. Although the objective of the performance measurements is questionable, the study supported previous research findings and provided further evidence for the importance of prenatal testosterone in adult sporting performance.

It appears therefore that those exposed to increased levels of prenatal testosterone have greater sporting ability. However, the exclusively male samples included in these studies limit the ability to generalise findings beyond that sub-group. Only two studies exist in which digit ratio was shown to be negatively associated with females' endurance running performance (Paul, Kato, Hunkin, Vivekanandan & Spector, 2006) and fencing ability (Voracek, Reimer & Dressler, 2010). Voracek, et al., (2010) reported some surprising results, specifically that 2D:4D only related to performance in females, not males. Previous studies had more success locating significant associations in males, rather than females. The authors noted that the long term extragenital effects of testosterone were apparent even when controlling for physiological and psychological indices such as age, body mass index, years of fencing experience, control, harm avoidance and social potency. However, the study

acknowledged that their list of control variables was not exhaustive, as many more physiological and psychological attributes relate to sporting success. Nevertheless, an association between 2D:4D and performance was identified.

This link between digit ratio and sport performance is thought to be multidimensional. Significant associations have been widely noted between physiological parameters (e.g., effective cardiovascular system, physical fitness and visuospatial ability) and 2D:4D. Behavioural differences, such as increased exercise frequency, have been identified in those with low 2D:4D, in comparison with high digit ratio (Honekopp, et al., 2006). Surprisingly, only one study considers psychological variables in relation to levels of prenatal testosterone exposure. Tester & Campbell (2007) assessed the relationship between 2D:4D, social potency and harm avoidance. Although no significant findings were reported (Tester & Campbell, 2007) this was a welcome direction for research. Since there is scarce research to guide the selection of relevant psychological constructs in relation to 2D:4D and sport, the current study rationalises the inclusion of the selected variables with reference to their proposed importance in sport performance.

One particular construct that may be deemed important in differentiating athletes' performance is mental toughness (Kuan & Roy, 2007; Golby & Sheard, 2004). The ability to regulate emotion and imagery effectively, display commitment and determination, and possess an uncontrollable desire to succeed and an unshakeable confidence, are all characteristic of mentally tough individuals (Crust & Clough, 2005). A further feature of mental toughness is the ability to adapt and cope in stressful conditions. Dealing successfully with competitive stressors also requires effective coping strategies. Individuals tend to have a preferred coping style, which can be defined as the individual's tendency to respond and resolve problems with a particular style of action (Bolger, 1990). Three categories of

response style: emotion, task and avoidance coping, were identified by Lazarus & Folkman (1984). Problem focused coping is a pragmatic style: individuals utilising this resource tend to establish practical and systematic solutions to their stressors and resolve problems through this method. Emotion focused coping alludes to an individual's use of emotional strategies to cope, e.g., off-loading emotion through communicating with social support networks. Finally, avoidance coping strategy, also known as the least adaptive coping style, includes strategies that attempt to avoid or lessen the perceived severity of the problem or stressor, e.g., substance abuse and thought avoidance. As noted in Chapter II, Nicholls, et al., (2008) identified an association between coping style (characterised similarly to Lazarus & Folkman, 1984) and mental toughness. Specifically, those highest in mental toughness tended to utilise more approach coping strategies and fewer avoidance tactics. Furthermore, an association between mental toughness and optimism was also reported. However, the cross-sectional nature of the study means that conclusions require further substantiation with different samples of sports performers.

The construct of optimism refers to individuals that appraise potential outcomes positively (Burke, et al., 2000) or typically expect their life outcomes to be positive in nature. Previous research has suggested that optimism is the most important predictor of sporting achievement in cross country skiers and swimmers (Norlander & Archer, 2002). Moreover, several psychological variables that are associated with sporting success are significantly related to optimism, including the direction of anxiety interpretation (Wilson, Raglin & Pritchard, 2002). Specifically, athletes with a more optimistic disposition experienced increased facilitative anxiety perceptions (Wilson, et al., 2002).

Additionally, an individual's motivation to compete and succeed in sport is important in determining levels of application (Ntoumanis, 2001). One existing motivation theory that

has received widespread attention in several domains including sport is the achievement motivation theory (Duda & Hall, 2001). The model emphasises the importance of goal orientation and proposes two distinct ego and task orientated goal categories. Duda & Treasure (2001) suggest that performers with adaptive, high task and ego goal orientations are better equipped to meet the demands of sport. Research has suggested that task orientations are of greater benefit to sporting performance, since they promote more self-determined cognitions/behaviours, self-control, regulation (Gano-Overway, 2008) and greater enjoyment (Spray, Biddle & Fox, 1999). In an examination of gender differences, Spray, et al., (1999) highlighted the male preference for ego goals and an increased rate of boredom in task orientation conditions.

Aggression serves as the final psychological factor included in this study, and may be positively associated with prenatal testosterone levels (Bailey & Hurd, 2005). In a sporting context, aggression is related to the athletes' tendency to "force action" (Kerr, 2004). Wilson (1983) found that women with low 2D:4D were more assertive and aggressive. Several studies have shown a negative correlation between aggression and 2D:4D (Bailey & Hurd, 2005). Further evidence is necessary to substantiate this relationship.

This exploratory study was designed to examine the potential of varying levels of prenatal testosterone to differentiate individuals' levels of mental toughness, preference of coping style, optimism, ego and task goal orientations and aggression, which are considered to be important prerequisites of sporting excellence.

3.3. METHOD

3.3.1. Participants

The participants in this study were an opportunity sample of 122 (male=60 and females=62) sports people from a North Eastern university categorised as 18-25 years (n=90) and 25+ years (n=32), from all levels of sporting achievement: International/national (n=23), Regional (n = 43), School/recreational (n= 56).

Participants included competitors from a range of sports, including swimming and climbing, and had between four and thirty years' experience of competition. The exclusion criteria included: those who had suffered an injury to the phalanges that may distort their digit ratio and those who suffered from congenital adrenal hyperplasia.

3.3.2. Measures

3.3.2.1. *Mental toughness*

The Alternative Psychological Performance Inventory (PPI-A; Golby, et al., 2007) was used to measure mental toughness. The questionnaire obtains an overall toughness score, and 4 sub scale scores: self-belief, determination, positive cognition and visualisation. Responses are given on a five point Likert scale, which ranges from 'almost always' to 'almost never'. Collectively satisfying absolute and incremental fit index benchmarks, the inventory possesses satisfactory psychometric properties, with adequate reliability and convergent and discriminant validity (Golby, et al., 2007).

The Sport Mental Toughness Questionnaire (SMTQ; Sheard, et al., 2009) was used as a secondary measure of mental toughness. The questionnaire yields a total mental toughness figure, and 3 subscale scores: confidence, constancy and control. There is preliminary support for the factor structure, reliability and validity of the measure (Sheard, et al., 2009).

3.3.2.2. *Aggression*

The Buss-Perry Scale (Buss & Perry, 1992) provides an overall value of aggression and four sub-scale measures: Physical aggression (9 items), Verbal aggression (6 items), Anger (6 items) and Hostility (8 items). Statements are rated on a seven point Likert scale, ranging from 'extremely characteristic of me' to 'extremely uncharacteristic of me'. The measure has acceptable psychometric properties (Buss & Perry, 1992) and has been previously administered to sports persons (LeMieux, McKelvie & Stout, 2002). The exclusion criteria for participants included any lasting injuries (particularly those that influenced their digit lengths) and those who had HOX gene related disorders (as this gene controls relative digit lengths).

3.3.2.3. *Optimism scale*

The Revised Life-Orientation Test (Scheier, et al., 1994) comprises of three positive items, three negative items and four filler items. Statements are rated on a five point Likert scale, ranging from 'strongly agree' to 'strongly disagree'. Scores range from 6-30, with a higher score representing greater optimism. Studies have shown the LOT-R to have acceptable validity and internal consistency (Smith, 2003). It is also appropriate in the assessment of athletes (Czech, Burke, Joyner & Hardy, 2002).

3.3.2.4. *Coping strategies*

Joseph, et al., (1992) selected thirty coping style items, which were also used in this study. Style can be grouped into three categories: emotion (10 items), problem (10 items) and avoidance coping (10 items) (Endler & Parker, 1990). Statements are rated on a four point Likert scale, ranging from '*I do this a lot*' to '*I never do this*'. The score for each conceptual grouping can range from 10 to 40; overall scores ranging from 30 to 120. Psychometric

properties of this measure are adequate (Joseph, et al., 1992). Support is given to the utilisation of this tool with competitive athletes (Nicholls, et al., 2008).

3.3.2.5. Goal orientations

The Task and Ego Orientation in Sport Questionnaire (Duda & Nicholls, 1992) contains thirteen items: six indicating ego orientation and seven showing a task orientation. Items were rated on a five point Likert scale, ranging from 'strongly agree' to 'strongly disagree'. Scores for ego orientation range from 6 to 30 and task orientation range from 7 to 35. The validity and internal reliability of this measure are deemed adequate (Ebbeck & Becker, 1994).

3.3.2.6. Digit ratio

Digit ratio was obtained using a flatbed scanner, which was then measured using Vernier Calipers (Fink, Neave, Laughton & Manning, 2006) by two independent researchers. The inter-rater reliability co-efficient was high ($\alpha=0.98$) indicating high measurement consistency. Both the left and right hands were measured, as previous studies have demonstrated that correlations between measured variables and left and right hands are notably different and therefore inclusion of the two hands will present a more balanced perspective of the utility of right and left hand 2D:4D measurements.

Digit ratio was also grouped into low ($n=61$) and high ($n=61$) categories. Mean digit ratio for males is 0.96 (Manning, 2002), standard deviation is 0.04; low group (0.90-0.96) which is one and a half standard deviations below the mean. High group (0.96-1.04) which is two standard deviations above the mean.

3.3.3. Procedure

Following approval from the University Ethics Committee, requirements of the study were explained to participants before they gave signed consent to take part in the research. The confidentiality of results was explained to participants, who then completed the battery of questionnaires. They were then required to provide a digital hand scan of both hands, which were computed using Vernier Calipers (Fink, Duche, Lac & Robert, 2006). Finally participants were reminded of their right to withdraw from the study.

3.3.4. Data analyses

To explore the nature of the relationship between 2D:4D digit ratio and psychological variables, digit ratio was dichotomised using a mean split. Sport achievement level digit ratio group differences for each measured psychological characteristic were explored using a multivariate analysis of variance (MANOVA). Alpha was set at 0.05. Gender was entered as a control variable as 2D:4D is a sexually dimorphic trait.

Recent studies have been criticised for including several measures of digit ratio within a single analysis (left/right hand), as it increases the probability of Type 1 error. Whilst the current research acknowledges this argument, Bonferroni correction compensates for this potential error. For the post-hoc tests, significance was set at $p < 0.025$. Moreover, as 2D:4D is a sexually dimorphic trait, gender was entered as a covariate to negate the influence of this demographic variable upon the results.

3.4. RESULTS

Means and standard deviations of all measured variables are presented in Table 3.1.

Table 3.1: Means and standard deviations of all measured variables, separated by digit ratio.

Variable	Mean (SD) low digit ratio (0.90-0.96)		Mean (SD) high digit ratio (0.97+)	
	Right hand	Left hand	Right hand	Left hand
PPI				
Determination	12.57 (1.89)	12.63 (1.92)	10.26(2.80)	10.34 (2.72)
Self Belief	15.15 (2.85)	15.32 (2.79)	11.78 (3.34)	11.79 (3.27)
Positive Cognition	15.63 (2.33)	15.68 (2.37)	12.26 (2.88)	12.41 (2.84)
Visualisation	12.50 (2.9)	12.53 (2.96)	8.33 (3.16)	8.59 (3.19)
SMTQ				
Confidence	17.30 (3.72)	17.37 (3.76)	13.63 (2.87)	13.79 (2.85)
Constancy	13.05 (2.08)	13.13 (2.10)	11.48 (2.82)	11.48 (2.72)
Control	11.60 (2.37)	11.61 (2.43)	10.22 (2.74)	10.31 (2.66)
Optimism	22.30 (3.63)	22.29 (3.71)	19.89 (3.88)	20.07 (3.82)
Task coping	29.53 (3.97)	29.66 (4.03)	29.33 (4.91)	29.17 (4.77)
Emotion coping	25.70 (4.32)	25.84 (4.39)	27.04 (4.93)	26.76 (4.87)
Avoidance coping	22.55 (4.43)	22.55 (4.55)	22.74 (5.94)	22.72 (5.73)
Aggression				
Anger	19.11 (5.44)	18.86 (5.47)	20.67 (8.42)	20.88 (8.13)
Physical aggression	24.21 (9.25)	24.47 (9.42)	24.17 (11.34)	23.81 (10.97)
Hostility	15.13(5.81)	15.25 (5.83)	20.87 (11.27)	20.27 (11.11)
Verbal aggression	20.68 (6.64)	20.92 (6.75)	20.75 (8.70)	20.42 (8.43)
Task goal orientated	29.10 (3.23)	29 (3.27)	26.33 (4.56)	26.66 (4.56)
Ego goal orientated	17.65 (5.02)	17.7(4.74)	15.15 (5.54)	15.03 (5.72)

There was a significant multivariate effect for right hand digit ratio, Wilks $\lambda = 0.581$, $F(1, 121) = 4.04$, $P < 0.001$, partial $\eta^2 = 0.419$, with significant differences observed in eleven of the seventeen dependant variables.

Specifically, there were significant group differences in: *determination* $F(1, 121) = 23.22$, $P < 0.001$, partial $\eta^2 = 0.162$; *self-belief* $F(1, 121) = 20.75$, $P < 0.001$, partial $\eta^2 = 0.147$; *positive cognition* $F(1, 121) = 34.72$ $P < 0.001$, partial $\eta^2 = 0.224$; *visualization* $F(1,$

121) = 44.55 $P < 0.001$, partial $\eta^2 = 0.271$; *confidence* $F(1, 121) = 17.68$ $P < 0.001$, partial $\eta^2 = 0.128$; *constancy* $F(1, 121) = 7.604$ $P < 0.01$, partial $\eta^2 = 0.060$; *control* $F(1, 121) = 18.069$ $P < 0.001$, partial $\eta^2 = 0.131$; *optimism* $F(1, 121) = 9.989$ $P < 0.01$, partial $\eta^2 = 0.077$; *ego goal orientation* $F(1, 121) = 4.013$ $P < 0.05$, partial $\eta^2 = 0.032$; *task goal orientation* $F(1, 121) = 9.654$ $P < 0.01$, partial $\eta^2 = 0.074$ where those with a lower digit ratio scored higher than those with high 2D:4D. A significant group difference was located in relation to *hostility* $F(1, 121) = 15.095$ $P < 0.001$, partial $\eta^2 = 0.112$, where those with high 2D:4D reported significantly greater levels.

There was also a significant multivariate effect for left hand digit ratio, Wilks $\lambda = 0.522$, $F(1, 121) = 3.98$, $P < 0.001$, partial $\eta^2 = 0.388$. All significant effects shown for right hand are identical for left hand ratio.

Moreover, there was a significant multivariate effect for sporting level of achievement, Wilks $\lambda = 0.00$, $F(1, 121) = 3.505$, $p < 0.001$, partial $\eta^2 = 0.366$, with significant differences observed in 15 of the dependant variables. Means and standard deviations of all variables displaying significant findings are contained in Table 3.2, and post-hoc analysis is presented in Table 3.3. Discriminant analysis revealed that visualisation and hostility best predicted digit ratio group membership (see Table 3.4 for a summary).

Table 3.2: Means and standard deviations of each significant variable, separated by level of sporting achievement.

Variable	Sporting level of achievement: Mean (SD)		
	1	2	3

Emotion coping	26.7 (2.584)	25.147 (4.806)	28.677 (4.366)
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Variable	National – Regional (presence of significant effect)	National – Leisure (presence of significant effect)	Regional – Leisure (presence of significant effect)

Task goal orientated	30.8 (3.490)	27.794 (3.804)	26.889 (4.351)
Ego goal orientated	20.3(4.057)	15.971 (4.796)	14.278 (5.454)
Determination	13.8 (1.398)	11.706 (2.263)	10.333 (3.049)
Self Belief	16.2 (2.150)	14.118 (3.756)	11.611 (2.660)
Positive Cognition	16.7 (2.003)	14.765 (2.133)	11.778 (3.405)
Visualisation	14.6 (1.955)	11.118 (3.033)	8.278 (3.739)
Confidence	19.7 (3.592)	15.853 (3.526)	13.333 (2.787)
Constancy	13.8 (1.299)	12.647 (2.497)	11.333 (2.59)
Right hand digit ratio	0.944(0.01838)	0.961 (0.03239)	0.979 (0.02555)
Left hand digit ratio	0.945 (0.1354)	0.959 (0.02858)	0.981 (0.2471)

Table 3.3: The results of the post-hoc ANOVA analysis.

Emotion focused coping	No	No	Yes
Task goal orientation	No	Yes	No
Ego goal orientation	Yes	Yes	No
Determination	Yes	Yes	No
Visualisation	Yes	Yes	No
Self belief	No	Yes	Yes
Positive cognition	No	Yes	Yes
Constancy	No	Yes	No
Right hand digit ratio	No	Yes	No
Left hand digit ratio	No	Yes	No
Confidence	Yes	Yes	Yes

Table 3.4: Summary of discriminant analysis:

Step	Entered	Wilks Lambda						
		Exact F						
		Statistic	Df1	Df2	statistic	Df1	Df2	P value
1	Visualisation	0.662	1	1	30.606	1	60	0.001
2	Hostility	0.608	2	1	19.030	2	59	0.001

3.5. DISCUSSION

The present study aimed to establish the relationship between 2D:4D and several psychological variables, selected for their relevance to sporting success. It is the first study, within this domain, to focus on this particular combination of variables and to utilise a sample

of mixed gender. Sexual dimorphism was observed in digit ratio, as expected (Manning, 2002), with males demonstrating lower values ($p < 0.001$).

The main findings substantiate previous research, which recognises the sporting ability and 2D:4D relationship: those with high prenatal testosterone exposure (low 2D:4D) possess greater aptitude within sport (Manning, 2002; Manning & Taylor, 2001; Honekopp, et al., 2006). This difference was significant when comparing the highest (international/national) and lowest (leisure/school) groups; perhaps there is a threshold for prenatal testosterone's influence upon sporting ability. There was no significant difference between regional level and leisure, or regional level and national/international level. Previous research has found similar results; Golby & Sheard (2004) found that international/national level rugby players were significantly more mentally tough than their leisure athlete counterparts. The psychological differences identified among performers, competing at different sporting levels in this study, may illuminate the nature of this relationship.

Athletes participating in the lower level of sporting achievement, selected emotion focused coping as the preferred style, significantly more than regional level individuals. They also reported lower levels of the subcomponents of mental toughness, including: self-belief, confidence and positive cognition. Research has suggested that a greater level of self-confidence is associated with an increased sense of influence over one's life outcomes. This sense of empowerment, coupled with increased positive cognition, could relate to higher levels of emotional stability (Gucciardi, et al., 2008). This would indicate less use of emotion focused strategies, which is characteristic of the mentally tough person. Such a finding is congruent with previous cross-sectional research in this area: Nicholls, et al., (2008) found that mental toughness suggested greater utilisation of problem-focused strategies. Despite this, no differences were identified in individuals' use of avoidance and approach coping

strategies. Perhaps the unique ability of mentally tough, high performing individuals is in their appropriate, varied selection of coping strategies, according to the stressor presented at that time. Future longitudinal research that tracks an individual's selection of coping strategies and type of stressor faced at that time, may wish to address this claim.

It was also revealed that those competing at an international/national standard and with low 2D:4D scored significantly higher than those competing at all lower levels and with high 2D:4D. Perhaps those competing at an elite level are likely to be frequently exposed to visualisation and imagery techniques (MacIntyre & Moran, 2007). They may possess greater determination, because of the enhanced work ethic necessary to succeed (Holland, Woodcock, Cumming & Duda, 2010). Furthermore, the competitive nature of sport and constant performance comparison among athletes is likely to increase the use of ego goals (Stornes & Ommundsen, 2004). Cross-sectional research detracts from making causal inferences, i.e., does individuals' mental toughness increase due to participation in high level sport? Or does being mentally tough allow an individual to compete at such a competitive tier? Future research may wish to explore such ongoing research questions.

Significant differences were also identified in other mental toughness subscales. Specifically, those competing at higher levels (international/national) and with low 2D:4D scored higher on the subscales of control (SMTQ), confidence (SMTQ), self-belief (PPI-A) and constancy. This provides further support for the claim that these characteristics are important in sport performance (Gucciardi, et al., 2008; Crust, 2007; Golby & Sheard, 2004), and also highlights the potential of prenatal testosterone in partially explaining their development.

Furthermore, those with a low digit ratio scored significantly higher on the optimism scale. Researchers have suggested that optimism level may be an important factor in

determining the level of effort invested to achieve goals (Nicholls, et al., 2008) and is a significant predictor of success in cross country skiing (Norlander & Archer, 2002). Previous research has confirmed the positive association between optimism levels and mental toughness also, which was confirmed in the current study. It appears logical that those with a high sense of self belief and control over future outcomes would hold positive expectations of their future.

Interestingly, this study's findings in relation to aggression appear incongruent with previous 2D:4D research. Several studies had noted a negative relationship between all subscales of aggression and 2D:4D (Bailey & Hurd, 2005). The current study found that individuals with low 2D:4D and currently competing in higher levels of sporting achievement, reported significantly lower hostility. This appears to make sense when considering hostility in relation to sport: hostility was previously shown to be positively related to risk of injury (Galambos, Terry, Moyle & Locke, 2005) and negatively associated with the number of training hours undertaken in martial arts (Daniels & Thornton, 1992). Further research may wish to explore the exact mechanisms underlying this relationship.

The current study serves as preliminary research into the associations between 2D:4D and several psychological characteristics thought to be related to successful sporting achievement. Present findings support the notion that mental toughness is important when considering sporting performance, i.e., those with greater levels are more successful, although no causal inferences can be made at this stage in research.

Results highlight the scope for future research in this area, along with the measured proposal that prenatal testosterone exposure may partially explain adult sporting success and mental toughness levels. The possibility of talent selection based on digit ratio, although potentially plagued with ethical concern, highlights the need to further explore this

relationship. Additionally, the possibility of developing objective biological measures, such as 2D:4D ratio, to support self-reported measures of assessment, could significantly advance issues with measurement validity and reliability (Chalabaev, Major, Cury & Sarrazin, 2009). This topic is particularly relevant with some of the selected scales utilised in this study. The existing mental toughness measurement (Crust, 2007) and the Task and Ego Goal Orientation in Sport Questionnaire (Lane, Nevill, Bowes & Fox, 2005) have been subject to criticism. Perhaps future research may wish to employ sound existing psychometric measurements, in order to substantiate the relationship between prenatal testosterone (2D:4D) and psychological variables relevant to sport. A further noted limitation of this study includes its heterogeneous sample; addressing similar research questions within specific sports and levels may provide a more detailed insight. However, at an exploratory stage, establishing generalisable trends across a broad range of demographically different individuals were appealing.

The present study's findings suggest that hormonal differences may relate to an individual's mental toughness level. Specifically, those with increased exposure to prenatal testosterone typically demonstrate greater mental toughness. Perhaps future research might examine the relationship between circulating hormones and aspects of mental toughness. In particular, the adrenocorticoid termed cortisol might be a potentially important hormone to consider, as it has been used as an accurate marker for perceived stress levels (Ehrlenspiel & Strahler, 2012). Since mentally tough individuals are thought to experience lower levels of stress, more facilitative and accepting views of competitive anxiety and increase perceptions of challenges rather than threats, it would appear logical that such psychological differences would also manifest in terms of physiological functioning. Hence, examining the association between stress related, circulating hormones and mental toughness may advance our

understanding of the mentally tough performers' response to competitive stress and provide evidence for the hypothesised physiological differences associated with the construct (Gucciardi, et al., 2008).

CHAPTER IV: EXAMINING PSYCHOLOGICAL DETERMINANTS OF THE ACUTE CORTISOL RESPONSE TO COMPETITION IN NATIONAL LEVEL SWIMMERS.

“Before aligning the mind, body and soul ... first one has to straighten their mind out.” Stephen Richards.

4.1. ABSTRACT

This study aimed to identify an association between the cortisol response to stress (competition), mental toughness and also the relationship with swimming performance. A cross-sectional design that included 41 (male = 17, female = 24) national competitive swimmers was utilised and total cortisol release (Area Under the Curve) over a competitive event (three measurements one week prior to the event, immediately before the swim and 15 minutes, 1 and 4 hours post-race) was measured along with selected characteristics of mental toughness (confidence, anxiety, resilience, persistence and consistency). The results demonstrated that the adaptive psychological variables were associated negatively with total cortisol output, i.e., facilitative cognitive anxiety interpretations and resilience. Those swimmers that reported high scores on resilience and low cortisol levels demonstrated the most successful performance. The findings suggest that more complex and interactive relationships are present between physiological and psychological variables that are involved in the stress response, and therefore the selected statistical models should reflect these complex relationships.

In conclusion, it appears that characteristics of mental toughness may be related to a reduced peripheral physiological response to competition and are associated with successful performance. Hence, the previous claim generated from qualitative research, that mental toughness buffers against stress, received initial empirical support. However,

the cross-sectional nature of the study means that drawing confident conclusions is problematic. Nevertheless, the study highlights several novel and exploratory relationships. Future research may wish to explore these important associations in different sports and contexts.

4.2. INTRODUCTION

The human stress response involves a complex signaling pathway involving neurons and somatic cells. The hypothalamic-pituitary-adrenal (HPA) axis is one of the physiological systems involved in this response and its activation results in the secretion of several hormones, including cortisol (for an overview, see Ehrlenspiel & Strahler, 2012). Cortisol has several important functions, including homeostatic metabolism regulation and preparation for a stress response, i.e., fight or flight (Marin & Birketvedt, 2010). This response has several acute influences upon physiological functioning, including increased ATP uptake, that are beneficial for performance. However, consistently elevated cortisol levels have been shown to relate to a state of distress and perceived threat (Dickerson & Kemeny, 2004). Researchers have examined both intra and inter-individual differences in response to stress and particularly the importance of relevant personality characteristics.

Sport is a competitive and stress eliciting arena (Rohleder, Beulen, Chen, Wolf & Kirschbaum, 2007) in that it encapsulates perceived uncontrollability (competitors, external factors), unpredictability (competitors/competitive variables) and requires ego involvement (winning) (Biondi & Picardi, 1999). Previous research has explored the psycho-physiological responses of sports performers during competition (Strahler, Ehrlenspiel, Heene & Brand, 2010).

Filaire and colleagues, for example, found an anticipatory rise in cortisol in female gymnasts during weeks leading up to a competition, as compared with levels observed in a control group (Filaire, Michaux, Robert & Lac, 1999). Similar results were found in tennis (Salvador, Suay, González-Bono & Serrano, 2003) and dance (Rohleder, et al., 2007). They concluded that a sport competition serves well as a real life stressor to activate the HPA. Inter-individual differences in cortisol concentration prior to and during stressful situations are apparent across several research studies and have been partially attributed to psychological individual differences. However, relatively few research studies have attempted to explain hormonal fluctuations or changes arising from psychological features of behaviour.

A relatively novel study found a positive association between perfectionism and cortisol release when performing a psychosocial stress task (Trier Social Stress Test). Hence this research provides initial evidence for the importance of a trait variable when considering responses to stress (Wirtz, Elsenbruch, Emini, Rudisuli, Groessbauer & Ehlert, 2007). Moreover, positive psychological traits such as optimism (Cohen, Kearney, Zegans, Kemeny, Neuhaus & Stites, 1999) and self-efficacy (Wu'st, Federenko, Hellhammer & Kirschbaum, 2000) have been linked with variation in neuroendocrine response. Eubank, Collins, Lovell, Dorling & Talbot (1997) found more elevated cortisol and competitive anxiety responses in canoeists categorised as "debilitators" before a competition. More recently, researchers have demonstrated an association between both emotional and hormonal homeostasis (reduced cortisol response and more stable emotional reaction) and basic psychological needs' satisfaction, i.e., a theory of motivation, grounded in the self-determination literature (Quested & Duda., 2011). Hence, the authors alluded to the significant omission in the literature, as relatively few research studies have assessed the association between important psychological variables and hormonal homeostasis. However, whilst more trait-like, stable

psychological variables are associated with the stress response, the influence of situational variables should not be ignored. For example, perceived importance and satisfaction of a competitive event have been shown to relate to cortisol secretion (Kuczka & Treasure, 2005).

One stress-buffering construct termed mental toughness has been argued to be involved in this process (Clough, et al., 2002; Jones, et al., 2007) and has thus far has not received attention in the context of physiological stress response research, although it may play an important role in the psychophysiological response to competition. However, the literature on mental toughness has struggled to establish a definitional consensus, wherein no single conceptualisation of mental toughness has emerged as adequate, with regard to construct validity and theoretical underpinning. Therefore, the conceptual approach adopted in the current study is to select the central characteristics of mental toughness (as reported widely by many conceptual studies) and utilise existing, credible psychometric measures, rather than mental toughness measurements. This was deemed particularly important as the differences in cortisol secretion can be subtle, and psychometrically sound psychological measures generally illuminate more subtle relationships. Moreover, the study was also designed to capture state (competitive anxiety) variables across the measured competitive event.

Previous research has linked some of the characteristics of mental toughness with the stress response. For example, sport performers with facilitative anxiety views (characteristic of mental toughness; Gucciardi, et al., 2008) produce less cortisol prior to competition, in comparison with those with more debilitating perceptions (Gaab, Rohleder, Nater & Ehlert, 2005; Bollini, Walker, Hamann & Kestler, 2004; Eubank, et al., 1997; Kim, Chung, Park & Shin, 2009; Hodgson, Draper, McMorris, Jones, Fryer & Coleman, 2009). This finding has been replicated across different sports, including rock climbing (Kim, et al., 2009), golf

(Hodgson, et al., 2009) marathon canoeing (Eubank, et al., 1997) and tennis (Filaire, Ferrand & Verger, 2009). But these studies utilise limited sample sizes (average $n=15$) and consider only the anticipatory rise (increase from resting to precompetitive state) alone. Research into the neuroendocrine response suggests that recovery from stress has an impact upon subsequent performances (Brownlee, Moore & Hackney, 2005).

Psychological factors have been deemed more important than merely performance outcomes, such as winning and losing in tennis (Suay, Salvador, Gonzalez-Bono, Sanchis, Martinez, Martinez-Sanchis, Simon & Montoro, 1999). These authors failed to locate significant differences between those who won and individuals who lost. However, winning and losing appears to be a crude measure of performance, particularly within the open skilled sport of tennis. An individual's performance outcome is also dependent upon the performance of other competitors and the umpire's decisions. Elsewhere, research has demonstrated that the hormonal release (specifically testosterone concentrations) is significantly related to the appraisals (attributions of success) of basketball players following a competitive match. Those with external attributions of success typically had lower concentrations of testosterone, whereas the losing team showed the opposite effect, i.e., those with external attributions of failure had higher levels of testosterone. It appears that attributions of success/failure have an important association with hormonal functioning, and concentrations of these hormones have been shown to predict whether sports people choose to engage in competition again. An evolutionary perspective suggests that individuals who have greater releases of testosterone are prepared to fight for status and therefore are more likely to engage in battle (competition).

A further important psychological variable that may be related to HPA activity, in an educational setting, is that of self-efficacy (Schwerdtfeger, Konermann & Schonhofen, 2008).

Self-efficacy was shown to be associated negatively with cortisol release, following an exercising task (Butki, Rudolph & Jacobsen, 2001). It is also suggested that mental toughness includes having an unshakeable belief in one's abilities (Jones, et al., 2002, highlighting the possible importance of self-confidence in regard to the stress response. Moreover, other research suggests that mental toughness may be important in this physiological response; optimism shares a positive relationship with mental toughness scores (Golby & Meggs, 2011) and those who report the highest levels of optimism also demonstrate a reduced neuroendocrine awakening response (Endrighi, Hamer & Steptoe, 2011). Taken together, previous studies into the stress response and research on mental toughness, suggest that mental toughness might be associated with acute HPA activation prior to, during, and after competition.

Therefore, this study was designed to continue the research into the biological basis of mental toughness. In doing so it sought to investigate the relationship between cortisol concentration over a stressful competitive event and central aspects of the construct of mental toughness (as measured by individual self-report measures). In line with previous findings (Filaire, et al., 2009), it was anticipated that participation in competition would lead to an increase in acute salivary cortisol concentrations for all swimmers (in comparison with resting levels), but that total cortisol release over the competition race would be higher in those with lower self-reported mental toughness. Furthermore, those with a reduced cortisol response and greater mental toughness would perform better than those with a pronounced stress response and low mental toughness.

An ecologically valid field study provided a welcome addition to the current literature, since it considered the entire pre-competitive and post-competitive stress reaction, in order to assess anticipation and recovery responses. Possible advancements offered by this

study include an understanding of how mental toughness manifests physiologically, possible explanations for its proposed link with optimal performance, and extended the quest initiated in Study I; to provide evidence for potential objective indicators of mental toughness levels in sport (Golby & Meggs, 2011).

4.3. METHOD

4.3.1. Participants

Participants were recruited from North-East England and Australian Swimming Clubs. Forty-one competitive (male $n=17$) swimmers ($M_{\text{age}} = 15.2$ years) from England and Australia ranged from national ($n=38$) to international ($n=3$) standard. The amount ($M_{\text{hours}} = 32.4$, $S.D. = 1.34$) and intensity (all swimmers were in a heavy/intense phase) of training leading up to the competition was similar for each participant, as these factors have been shown to influence cortisol levels (Rohleder, et al., 2007).

Prior to taking part in the study, all participants were informed of their right to withdraw, and ethical clearance was provided by the University Ethics Committee.

4.3.2. Measures

4.3.2.1. Competitive Anxiety. The CSAI-2R - Revised Competitive State Anxiety Inventory-2 (Cox, Martens & Russell, 2003) measures cognitive state anxiety (5 items), somatic state anxiety (7 items) and self-confidence (5 items) in a competitive setting. Respondents rate their feelings before competition (e.g., "*I feel jittery*", "*I am concerned about losing*") on a scale anchored by 1 = not at all and 4 = very much so. Participants then rate their directional interpretations of each anxiety statement, i.e., on a scale from -3 (very debilitating) to 3 (very facilitative).

Subscale scores from the CSAI-2R are calculated by summing items in each subscale, then dividing by the number of items, and finally multiplying by 10. Score range is 10 – 40 for each subscale. Support for the factorial validity of the CSAI-2R has been reported (Cox et al., 2003; Terry, Lane & Shepherdson, 2005).

4.3.2.2. Motivation.

The revised Sport Motivation Scale (SMS-6; Mallett, Kawabata, Newcombe, Otero-Forero & Jackson, 2007) is a 24-item scale that measures seven different forms of motivation, reflecting varying degrees of self-determination (Deci & Ryan, 1985). Participants are required to answer the question “*Why do you participate in your sport?*” with given responses such as “*Because it allows me to be well regarded by people that I know*” on a 7-point scale anchored by 1 = does not correspond at all and 7 = corresponds exactly. The factorial validity of the measure has been supported (Mallett, et al., 2007).

4.3.2.3. Resilience.

The Academic Resilience Scale (Martin & Marsh, 2006) was adapted to suit sport specific settings. Participants were required to respond to 6 items, such as “*I don’t let a bad swim/performance effect my confidence*” anchored by a 7 point Likert scale ranging from 1 = strongly disagree to 7 = strongly agree. Support for the factorial validity of the measure is reported by Martin & Marsh (2006).

4.3.2.4. Grit.

The Grit scale (Duckworth, et al., 2007) is a 12-item measure of perseverance and passion for long-term goals, with two subscales: consistency of interest (6 items): “*I often set a goal but later choose to pursue a different one*”, and perseverance and effort (6 items): “*Setbacks don’t discourage me*”. Respondents rate each statement on a 6-point Likert scale,

ranging from 1-very much like me, to 5- not like me at all. Support for the measures selected factors is provided by Duckworth & Quinn (2000).

4.3.2.5. Cortisol collection/assaying

To represent the unbound serum levels of cortisol, saliva samples (salivary cortisol level is a non-invasive and reliable marker of HPA activity; Strahler, et al., 2010) were collected at several time points (producing a volume of 1-3 ml for each sample).

Saliva sampling is an accurate measure of serum levels (the biological active fraction; Pearson-Murphy, 2000) correlations between the two values are highly significant, $r(47) = 0.91$, $p < 0.0001$ (Ellenbogen, Santo, Linnen, Walker & Hodgins, 2010). Participants, who were free of any medication (including the oral contraceptive pill), received instruction on salivation before each sampling stage (chew on the salivette swab for sixty seconds and place it into the plastic tube). Participants refrained from consuming food or caffeine one hour prior to their race and until the sampling procedure ended (Kudielkaa, Hellhammer & Wüstb, 2008). Participant administered samples are a reliable method of sampling when clear, concise instructions are provided and the individual has had prior practice (Hanson & Chen, 2010). Participants were all non-smokers, since smoking reduces activity of the HPA axis (Rohleder & Kirschbaum, 2006). They were neither on any medication, nor abusing drugs and had no history of endocrine disorders.

Samples were stored at around -30° Celsius and were subsequently thawed and centrifuged to separate the mucins prior to analysis. Salivary cortisol levels (nanograms per milliliter) were determined by using commercial enzyme-linked immunosorbent assay (ELISA) kits (Salivary Cortisol ELISA, SLV-2930, DRG Instruments GmbH, Germany) with

a sensitivity of 0.537 ng/ml, intra-assay variation of 1.80% ($M = 12.79$ ng/ml) and inter-assay variation of 7.16% ($M = 23.29$ ng/ml).

Cortisol calculations.

Two calculations of cortisol concentration were taken, firstly the baseline cortisol output (measurements were taken at the same times as the competitive event took place) and secondly the total cortisol release from pre-competition (-15 minutes) to four hours post-race (+20 minutes, 1 and 4 hours).

Total cortisol release was indexed via calculating Area Under the Curve (AUC) using trapezoid formulae (Pruessner, Kirschbaum, Meinschmid & Hellhammer, 2003). The baseline AUC score was then subtracted from the competition AUC index, in order to represent the difference in total cortisol release on the day of competition, compared to the individual's own resting state (baseline measurement). Although accurate and reliable cortisol testing would ideally require many cortisol measurements (assessing the cortisol awakening response), the applied nature of the testing environment did not allow for such thorough assessment. However, the measurements provided an adequate indication of the acute stress response to a competitive event, in an ecologically valid study.

4.3.2.6. Performance measures

Each participant performed a 100M sprint event in a national level competition. Performance was calculated by subtracting personal best time from the time swum in the measured competitive event, in order to establish the level of success of the performance.

4.3.3. Procedures

A baseline cortisol measure was established exactly one week prior to the competition (three measurements were taken, one hour apart), at the same time of day as the swim event

(the baseline and competitive day sampling took place between 2-6pm for all participant, in order to reduce the influence of the circadian rhythm of daily cortisol secretion upon results). Half an hour prior to the swim event, participants completed the survey package containing self-report questionnaires. The anticipatory cortisol measurement was taken immediately before the swim event commenced, i.e., 15 minutes prior to the event (the swim occurred between 2-3pm and the saliva measurement intervals were constant for each participant) and the recovery period was assessed at 20 minutes, one and four hours following the competition. These time frames were used, as previous research suggests that the most rapid recovery occurs within the first twenty minutes and it is expected that four hours is sufficient time for the body to return to homeostasis (Elloumi, Maso, Michaux, Robert & Lacin, 2003). Moreover, these timescales have been utilised by previous research to capture the acute HPA response to sport competition (Quested, Bosch, Burns, Cumming, Ntoumanis & Duda, 2010).

Participants also provided responses (on a Likert scale from 1-9) to measures of perceived importance, satisfaction (Kuczka & Treasure, 2005) and effort (Filaire, Duche, Lac & Robert, 1996) following the competitive swim. These state variables have been shown to influence cortisol release and therefore were designed to act as control variables in the current study.

4.3.4. Data analyses

4.3.4.1. Preliminary analysis

The descriptive data (Table 4.1) demonstrated satisfactory levels of skewness and kurtosis values and therefore normality was assumed. The data also indicated homogeneity of variance. Therefore, Pearson's Correlation Coefficient was conducted and identified any significant relationships between AUC, psychological variables and performance.

Furthermore, variables that significantly correlated with swimming performance were entered into a hierarchical regression analysis (cognitive anxiety interpretation and resilience).

Additionally, a one way repeated measures ANOVA was performed to determine the change in cortisol level from basal to pre-competitive measurements.

4.3.4.2. Focal Analyses

Those psychological variables (cognitive anxiety interpretation and resilience) that were found to be significantly correlated with performance and the physiological measures (baseline AUC and competition AUC) were regressed onto performance scores. Gender, age, perceived satisfaction, effort and importance were entered as control variables, to eliminate the influence of these salient variables upon performance. The main effect variables were entered on Step 1 (and zero-centred to test interactions on subsequent steps; Aiken & West, 1991). On Step 2, the three possible two-way interactions were entered (resilience x AUC, Cognitive anxiety x AUC and cognitive anxiety x resilience).

4.4. RESULTS

The participants' baseline cortisol levels were in the normal range (Dorn, Lucke, Loucks & Berga, 2007). The means and standard deviations of all measured variables are presented in Table 4.1. Significant correlations were identified between specific psychological variables (displayed in Table 4.2), cortisol release and performance. There was a significant association between cognitive anxiety direction and performance ($r = -0.385$, $p < 0.05$) and a significant correlation between self-confidence direction and performance ($r = -0.281$, $p < 0.05$). Moreover, a significant association between resilience and total cortisol output ($r = -0.313$, $p < 0.05$) was identified and also between the interpretation of cognitive anxiety and cortisol output ($r = -0.275$, $p < 0.05$).

Table 4.1: Means and standard deviations of all measured variables

Variable	Mean (S.D)
Cognitive anxiety intensity	14.49 (7.77)
Cognitive anxiety interpretation	-2.15 (4.41)
Somatic anxiety intensity	16.76 (6.50)
Somatic anxiety interpretation	0.17 (6.55)
Self-confidence intensity	16.59 (7.33)
Self-confidence interpretation	6.78 (6.74)
Resilience	26.73 (7.15)
Consistency of efforts	19.1 (3.46)
Perseverance of efforts	21.15 (3.61)
Amotivation	7.15 (4.76)
External regulation	15.90 (5.21)
Introjected regulation	14.63 (4.88)
Identified regulation	18.51 (3.40)
Integrated regulation	17.68 (4.91)
Intrinsic motivation	19.37 (4.60)
Performance (Number of seconds difference from personal best time)	0.29 (3.48)
AUC (Total cortisol release)	2.12 (1.41)

Table 4.2: Correlations between all variables

	CAI	CAD	SAI	SAD	SCI	SCD	R	CE	PE	AM	ER	IR	IDR	INR	IM	AUC	P
CAI		-.86	.464**	-.9	.525*	.199	.221	.084	.231	.024	-.292	-.221	-.061	0.23	-.13	-.15	-.04
CAD			-.28	.75**	.078	.33*	.107	-.25	-.074	.04	.014	.216	.018	.128	.015	-.275*	-.385*
SAI				-.203	.363*	-.210	.013	.026	-.133	-.02	-.262	.044	.055	-.05	-.301	.009	-.144
SAD					.075	.536*	.219	.023	-.009	-.09	-.013	.078	-.155	.279	-.02	-.227	-.112
SCI						.366*	.179	-.012	.37*	-.297	-.156	.032	.043	.333*	.005	-2.42	-.09
SCD							.332*	-.006	.428*	-.25	.08	-.073	-.114	.457**	.11	-.259	-.281*
R								.13	.438*	0.252	-.069	-.108	.019	-.10	-.095	-.313*	-.231
CE									.387*	-.105	-.084	.051	-.133	.055	.122	.075	.006
PE										-.372*	-.075	.035	.084	.266	.409**	-.188	.041
AM											.227	.058	-.11	-.102	-.402**	.383*	.192
ER												.533*	.394*	.367*	.008	.163	-.044
IR													.182	.369*	.065	.002	.187
IDR														.253	.279	-.167	-.024

INR															.315 *	.223	.012
IM																-.267	.091
AUC																	-.165
P																	

KEY: CAI – Cognitive anxiety intensity, CAD – Cognitive anxiety interpretation direction, SAI – Somatic anxiety intensity, SAD – Somatic anxiety interpretation direction, SCI – Self-confidence intensity SCD – Self-confidence interpretation direction, R – resilience, CE – Consistency of efforts, PE – Perseverance of efforts, AM – Amotivation, ER – External regulation, IR – Introjected regulation, IDR – Identified regulation, INR – Integrated regulation, IM – Intrinsic motivation, AUC – total cortisol release, P - performance.

* $p < 0.05$, ** $p < 0.01$, $p < 0.001$.

4.4.1. The competitive event

There was a significant difference in cortisol level between participants' resting baseline concentration and their pre-competitive levels: $F(1, 40) = 84.29, P < 0.001$.

Therefore, the competitive event was perceived to create sufficient stress intensity to generate a significant anticipatory rise in cortisol.

4.4.2. Hierarchical regression

The criterion variable was swimming performance. Resilience and cognitive anxiety interpretation, along with AUC (total cortisol output) were entered as predictors in the regression analysis.

Cortisol. Total cortisol release did not significantly predict performance, $\beta = 0.079, p = .594$.

Resilience. There was a significant main effect for resilience, $\beta = -.56, p = .001$. Swimmers with greater resilience performed significantly better than those swimmers who reported lower levels.

Cognitive anxiety interpretation. There was a significant main effect for cognitive anxiety interpretation, $\beta = -.471, p = .007$. Those with more facilitative views performed significantly better than those swimmers who reported less facilitative interpretation of anxiety.

Interaction effects. There was a significant resilience x AUC interaction, $\beta = -.44, p < .04$. Swimmers who reported the highest levels of resilience and secreted lower levels of cortisol had the most successful performances in the timed swim (in comparison with their previous personal bests).

4.5. DISCUSSION

The present study extended the line of psychophysiological enquiry initiated in Study I and investigated the association between cortisol concentration (neuroendocrine stress response), specific psychological aspects of mental toughness. Moreover, the relationship between psychophysiological response to competition and swimming performance was also examined. Self-report measures of the selected psychological variables indicated levels of mental toughness and the salivary cortisol measure provided a reliable marker of HPA activity (Strahler, et al., 2010). Recent research has utilised sport competition as an ecologically valid stressor, in which to explore psychological differences in relation to HPA activity in response to stress. The sporting arena poses many stressors and athletes must employ effective coping strategies and appraise such challenges in an adaptive way, in order to be successful (Kivlighan, Granger & Booth, 2005). Therefore it was deemed an appropriate arena in which to explore the relationship between potentially important personality variables and HPA activation.

As anticipated, the competition event generated significant cortisol increases for the swimmers ($p < 0.001$) and therefore the sporting event was characterised as stressful, as has been shown by previous research (Filaire, et al., 2009). Some research studies have suggested that habituation occurs rapidly for athletes, as they are exposed to competition regularly. However, the appraisal of the competition as important is likely to have contributed to the pronounced stress response (all swimmers reported scores of 5+ on a 1-7 Likert scale of importance rating). As was previously predicted, significant associations were identified between aspects of mental toughness and total cortisol output. The findings in this study support previous research, in that the interpretation of cognitive anxiety significantly

predicted performance. However, contrary to some previous research findings, cognitive and somatic anxiety interpretations did not correlate with total cortisol output. Research of this nature measured only the anticipatory cortisol rise and therefore presented a limited perspective of acute HPA activation. The present study included assessing the recovery period immediately following competition, and therefore may have tapped into the appraisals of performance (research has shown that external or internal attributions following performance influence cortisol concentrations).

Further examination of the results suggests that perceived satisfaction, importance and effort did not significantly relate to acute cortisol secretion in this study. This suggests that state variables underscore the importance of more trait-like personality variables, when considering the stress response (as measured by cortisol release). Additionally, the data demonstrated that resilience and the interpretation of cognitive anxiety were significantly correlated with performance, i.e., those reporting greater resilience and more facilitative views of cognitive anxiety performed best in the competitive swim event (in comparison with their previous personal best time). Therefore, these mental toughness characteristics were included in further regression analyses.

Previous research highlighted a linear relationship between resilience and cortisol secretion (Haglund, Nestadt, Cooper, Southwick & Charney, 2007) whereas, present findings suggest that their association may be rather more complicated. For example, these data suggest that a significant interactive effect exists between resilience and cortisol response, when predicting swimming performance. The interactive effect suggests that individuals with the highest levels of resilience and lowest acute cortisol response were the most successful performers. Specifically, swimmers who reported high resilience, but also secreted high cortisol levels, performed slightly worse, followed by those with low resilience and low

cortisol levels, and the poorest performers were those with low resilience scores and high cortisol levels. Earlier research has suggested that resilient individuals are able to rebound from adversity and appear more insensitive to failure and stress (Tugade & Fredrickson, 2004). The results in this study imply that this insensitivity reduces the negative impact of physiological stress arousal (activation of the HPA axis) upon performance. Hence, those with higher resilience, yet relatively high cortisol level, are able to perform better than those with lower scores on resilience scales. It would therefore appear that resilience actually buffers individuals from the adverse effects of stress, in relation to sport performance.

In summary, previous research has suggested that mental toughness may relate to various physiological differences that are important in sport competition (Gucciardi, et al., 2008). Study I highlighted the potential importance of prenatal testosterone and the current study provides support for the salience of cortisol, when examining aspects of mental toughness and their relationship with performance. However, it must be noted that the development of such physiological variations and specific causal inferences are unknown at this exploratory stage, but quantitative support for the associations between mental toughness and physiological indices could aid in identifying important lines of research. Overall, the current study extended the biological line of research initiated in Study I and provides primary support for the notion that aspects of mental toughness (particularly resilience and interpretation of cognitive anxiety) are related to HPA activation (cortisol output) and performance.

It is important to note that the heterogeneous sample means that findings cannot be confidently generalised beyond competitive swimmers. It has been suggested that research

should consider the manifestation of mental toughness in different sports separately (Crust, 2007) i.e., athletes competing in wrestling are likely to require different aspects and levels of the construct than competitors in swimming. A similar consideration is relevant in hormonal research: individual's secretion of hormones can be dependent upon the situation, i.e., amount and type of physical exertion required, number of unpredictable/uncontrollable variables, standard and importance of competition. Therefore, it might be difficult to make valid comparisons across different sports. However, the results provide initial evidence that mental toughness may be an important construct when considering the stress response in sporting situations.

The study is the first to consider this particular combination of psychological variables and their relationship with cortisol patterning and performance, in an ecologically valid setting. It highlights the need for further research that examines the psychological determinants of the cortisol response to sport competition. This is particularly important as effective recovery from stress is imperative for performance in future competitions.

These results also suggest that merely examining relationships between cortisol and psychological variables, in an attempt to understand the buffering effect of personality variables and their association with performance, might be somewhat oversimplistic. Interactive effects between psychological variables and cortisol release and their combined influence upon performance provides a more detailed, subtle insight into response to stress. Future research should include large sample sizes where possible, in order to improve statistical power and also address cortisol responses in different sports and contexts, to establish the generalisability of the current study's claims.

Nevertheless, the importance of considering psychological correlates of cortisol response to competition is evident, particularly as research highlights the detrimental outcomes resulting from delayed HPA recovery following stress. Negative consequences include reduced memory and cognitive functioning (Newcomer, Selke, Nelson, Hershey, Craft, Richards & Alderson, 1999) and immunosuppression (Bauer, 2005).

Future research may attempt to assess social and developmental influences in relation to mental toughness, and their relationship with physiological markers such as cortisol. Furthermore, recent research emphasises the importance of considering multiple hormonal measures, e.g., cortisol and testosterone (T/C ratio), as biological markers of adaptation to training and recovery from sport (Jimenez, Aguiler & Alvero-Cruz, 2012). Hormones rarely operate in isolation, but rather in an interactive fashion, and hence an examination of their combined influence is important. In the holistic definition of mental toughness provided by Gucciardi, et al., (2008) cognitive factors were also explicitly mentioned. However, little research to date has attempted to examine these potential differences with reference to achievement in sport. Therefore, the next study presented in this thesis continues the holistic examination of mental toughness, and addresses the potential cognitive manifestations of the construct.

CHAPTER 5: SELF-STRUCTURE AND MENTAL TOUGHNESS: FROM THE RECREATIONAL TO THE ELITE ATHLETE

‘If you do not conquer self, you will be conquered by self’ – Napoleon.

5.1. ABSTRACT

Previous research has alluded to the possible physiological and cognitive-affective variables that underlie the construct of mental toughness. Qualitative research has suggested that mentally tough athletes have generally positive self-concepts, in that they have belief in their abilities and are able to adapt to cope with the demands of stressful circumstances and contexts. Thus far, research has demonstrated that mentally tough athletes typically cope with stress in a pragmatic fashion (problem focused coping style) but also have equivalent emotional reactions to those with lower levels of mental toughness. Perhaps a relevant cognitive affective model of the self would be a useful model to shed light upon the different structures associated with sport performers of varying levels of mental toughness. This study examined the relationship between cognitive-affective differences in self-structure and mental toughness in sports. The heterogeneous sample included 106 athletes from a range of sporting achievement levels (international, national, regional, and recreational) and of mixed gender (male $n=64$). Mental toughness was hypothesised to be related to the self-structure termed ‘evaluative integration’ (mixture of positive and negative self-beliefs in each self-aspect or role) because of its priori evidenced relationship with positive coping and stable self-esteem, whereas evaluative compartmentalised (segregates positive or negative self-beliefs into separate self-aspects or roles) self-structure was predicted to be associated with low mental toughness. As predicted, integration in individuals with positive self-concepts was associated with high mental toughness; and, overall, people with negative self-concepts (proportion of negative self-beliefs) had low mental toughness scores. Elite athletes

(international/national competitors) self-reported significantly more mental toughness (confidence, control and self-belief) than those at lower levels of competition. Interestingly, the “super” elite athletes (those competing at an international standard) were disproportionately more compartmentalised when compared to sport performers at lower tiers, even though this structure was generally negatively related to mental toughness. This novel result is discussed, along with the other findings, and the contribution to understanding of mental toughness is emphasised. Future research may wish to advance the current study’s claims and further establish the utility of the compartmentalisation model in the sporting domain.

5.2. INTRODUCTION

As previously noted, mental toughness encapsulates cognitive, affective and behavioural components (Bull, et al., 2005; Clough, et. al., 2002; Connaughton, et al., 2008; Crust & Clough, 2005). However, no quantitative research has sought to illuminate these specific cognitive variations to date. Research examining the subtle cognitive differences associated with mental toughness has the potential to support the convergent validity of the construct and help researchers to better understand the cognitive profile of the mentally tough performer.

The present study utilises research on a cognitive-affective model of self-concept structure (Ditzfeld & Showers, in press; Showers, 2002) to examine whether differences in self-regulation tendencies are related to mental toughness. The inclusion of this self-concept measure, highlighting the cognitive representation of positive and negative self-beliefs in important contexts, enables examination of (1) the relationship between self-concept structure and mental toughness measures and (2) the association between self-structure and sporting

achievement (i.e., examines the self-structure of the elite athlete). Hence, Showers' evaluative self-concept structure model has the potential to capture cognitive-affective differences (at the state and trait level) that previous qualitative research has suggested are important toughness (e.g., Bull, et al., 2005; Clough, et al., 2002; Crust & Clough, 2005).

Mental toughness definitions commonly include self-confidence, a positive self-concept, construing and appraising competition as challenging, displaying resilience and determination in the face of adversity, persistently and consistently striving to achieve goals, and controlling one's emotions (Bull, et al., 2005; Clough, et al., 2002; Crust & Clough, 2005; Gucciardi, et al., 2009; Thelwell, Greenlees & Weston, 2006). These cognitive factors may be related to an underlying self structural style. The evaluative self structure model may allow us to understand which self concept structure is most associated with mental toughness in sport.

Evaluative Self-Concept Structure

Showers' (1992, 2002) model of evaluative self-structure focuses on the organisation of positive and negative beliefs about the self, highlighting two structural "styles" labeled *compartmentalisation* and *integration* (See Appendix 1). The self-concept is considered multidimensional, comprising of various aspects of the self, such as important roles, states, and domains (cf. *working self-concept*; Markus & Wurf, 1987). An elite athlete includes the self-aspect of "*player*" in their self-representation, but also "*teammate*" and perhaps "*when experiencing anxiety*." When a particular self-aspect is salient, the athlete has access to a particular set of self-beliefs (e.g., *energetic*, *confident*, and *hardworking* in the player role). But, naturally, individuals also have selves unrelated to sport, such as role in the family (e.g., "*father*") or when participating in a leisure sport (e.g., "*Sunday golf player*"), which are also important in the overall self-concept. The present study views the sport-self as an important, but not all encompassing, arena to measure the cognitive-affective traits of athletes.

The evaluative self-model is concerned with self-beliefs associated with aspects across contexts, arising from bad and good circumstances (Ditzfeld & Showers, in press). Of particular importance is a person's distribution of positive and negative beliefs across self-aspects. Although roles related to sport are important to mental toughness, positive perceptions in a singular domain may obscure the self's "hidden vulnerability" (Zeigler-Hill & Showers, 2007), which may arise when a successful performer is threatened by failure. Hence, a broader scope on the self-concept is required to understand more basic trait cognitive-affective responses.

Evaluative compartmentalisation. An individual with a compartmentalised self-structure segregates their positive and negative self-beliefs into separate self-aspects: each self-aspect is either uniformly positive or negative. For instance, the athlete may see himself positively overall in his sporting domain (e.g., *successful, confident, quick, needed*), but wholly negatively after failures (*uncomfortable, frustrated, tense, incapable*). This self-belief organisation style extends across aspects, such that similar patterns should exist across sport and non-sport domains; for example, "*in relationships*" (*disagreeing, insecure, shy, frustrated*), "*with friends*" (*happy, giving, energetic*), or "*when relaxing*" (*comfortable, friendly, loveable*).

Evaluative integration. People with this structure tend to have a fairly even distribution of positive and negative beliefs across separate self-aspects. An individual may perceive themselves mostly positively in the sporting domain, yet also have accessible negative beliefs (e.g., *successful* and *needed*, but also *insecure* and *lazy*). Although the mixed accessibility of positive and negative beliefs may temper confidence overall, conversely, it may lead to thriving in adverse circumstances. For example, although a player feels *frustrated* and *tense*, she may mitigate her doubt by recognising that she is *capable* and *confident*.

Also important to the evaluative organisation model are the variables' differential importance (DI) and proportion of negative self-beliefs (neg). DI measures the extent to which people weight their positive and negative self-aspects as more or less important. Individuals who see their positive self-aspects as relatively more important than their negatives have higher trait self-esteem (Pelham & Swann, 1989; Showers, 1992). Additionally, neg measures the proportion of negative self-beliefs across aspects. Perceiving the self with a majority of negative self-beliefs is rarely beneficial. Not surprisingly, high neg is associated with low self-esteem and more negative trait mood (Showers, 1992; Ditzfeld & Showers, 2012a). Therefore, high neg seems to capture insecurities about the self, underlying low self-efficacy, which hinders performance across contexts (e.g., sports, social, academic). People with high DI (positive self-aspects are most important) or low neg are labeled *positively* compartmentalised or integrative; people with low DI (negative self-aspects are most salient) or high neg, are termed *negatively* compartmentalised or integrative.

Two decades of research on evaluative organisation have established a consistent pattern of correlates related to compartmentalisation and integration. Compartmentalisation is associated with especially high global self-esteem and positive trait mood when the self-concept is positive (high DI or low neg) and especially low self-esteem and negative mood when the self-concept is negative (low DI or high neg); integration is associated with moderate levels of self-esteem and mood (for reviews, Showers, 2002; Showers & Zeigler-Hill, 2012). Although positive compartmentalisation is associated with positive wellbeing outcomes (Showers & Ryff, 1996), a somewhat tenuous self-esteem foundation underlies the compartmentalised structure (i.e., unstable self-esteem; cf. Kernis, 2003). Zeigler-Hill and Showers (2007) showed that compartmentalised individuals were more responsive to the negative (and positive) events in their everyday lives (via diary studies); moreover, positive-compartmentalisation was associated with substantially lowered self-esteem following social

rejection in a computerised rejection task. In addition, compartmentalisation has been shown to be associated with slower recovery from negative mood (Showers & Kling, 1996) and also poorer reactions to stress in students' first year of college (Showers, Abramson & Hogan, 1998). Hence, compartmentalisation is seen as more emotionally labile whereas integration is viewed as emotionally stable.

Cognitive-Affective Self and Mental Toughness

Recently, Ditzfeld and Showers (in press) have construed evaluative self-organisation as a largely affect-mediated model of self. In this view, compartmentalisation is a product of affect reactivity, wherein people with more reactive affective cores respond more strongly to emotional stimuli and this response engenders greater cognitive access to positive or negative thoughts. Strong positive (or negative) feelings provide access to strictly positive (or negative) self-beliefs. Indeed, compartmentalisation is associated with a tendency to attend to and categorise concepts and faces that share emotional connections (Ditzfeld & Showers, 2011; 2012b). A compartmentalised individual may avoid negative thoughts about the self, through motivated attempts to be accepted socially or by avoiding situations that create negative thoughts of self. However, active avoidance probably does not spare an individual from self-threatening information at all times. During these instances, compartmentalised individuals appear particularly vulnerable, due to their emotion regulation difficulties. Negative affect initiates primarily negative self-beliefs. In other words, a positively compartmentalised person's strong outward expression of self-esteem may be thwarted by underlying insecurities, when faced with adversity.

The potential for failure and pressure is common in competitive environments, therefore an integrative self-structure style is predicted to be characteristic of athletes with greater mental toughness and those at higher levels of sporting achievement, when the self-concept is generally positive (high DI and/or low neg). The weaker affective reactive core

posited to underlie integration should allow an athlete to remain emotionally stable in the face of adversity. The prospects of failure and experience of negative affect following defeat may be less severe for integrative (mentally tough) rather than compartmentalised individuals (Showers & Boyce, 2008).

Mentally tough individuals arguably possess more realistic and rational self-concepts and are better at coping with stress (Nicholls, Levy, Polman & Crust, 2011). These qualities are often associated with integrative self-structuring (cf. Showers, 2002). Nicholls and colleagues (2011) suggest that mentally tough individuals tend to cope in stressful circumstances by applying rational solutions. Mentally tough individuals remain calm when confronted with stressful situations and are relatively unaffected by negative (or positive) feedback (Clough, et al., 2002; Horsburgh, et al., 2009). Specifically, less mentally tough individuals performed significantly worse following negative feedback, which appears analogous to vulnerable self-esteem in compartmentalisation (cf. Zeigler-Hill & Showers, 2007).

Overview

This study examined the association between measures of mental toughness and evaluative self-organisation, in order to explore the self-concept structure of the mentally tough athlete. In people with positive self-concepts, evaluative integration was predicted to be associated with greater mental toughness. Negativity of the self-concept (the amount of negative self-beliefs in the self-concept or the extent to which individuals rate their negative self-aspects as relatively important) was predicted to be negatively associated with mental toughness.

Additionally, this research examined whether mental toughness and evaluative organisation differences exist across different levels of sporting performance. Consistent with previous research (Golby & Sheard, 2004) PPI-A and SMTQ mental toughness scores were

predicted to be higher in individuals competing at higher levels of sporting competition. Moreover, positive evaluative integration was also predicted to be the structural style of high-achieving athletes. Previous research focusing on the “super elite” has been criticised for limiting the generalisability of findings across lower levels of sport competition and thus limiting the potential utility of the construct at such levels (Crust, 2007). Accordingly, the current study includes a sample of athletes across a range of sporting levels: international, national, regional, and recreational.

5.3. METHOD

5.3.1. Participants

Participants in this study were volunteers from an opportunity sample of 105 athletes (65 males) in the United Kingdom, containing the following ages: 18-25 (74%), 26-35 years (10%), and 36+ years (16%). These athletes were competing in all levels of sporting achievement: International (9), National (18), Regional (29), and School/recreational (49), ranging from 5 to 14 years of involvement in their chosen sport ($M = 7.5$ years, $SD = 1.33$); including wrestling, swimming, dancing, athletics, tennis, rowing.

A priori power analysis revealed that in order to detect effect sizes of 0.25, a sample size of 94 people is necessary (Faul, Erdfelder, Buchner & Lang, 2009), therefore the current sample was deemed appropriate in size.

5.3.2. Measures

5.3.2.1. Mental Toughness

Sport Mental Toughness Questionnaire (SMTQ; Sheard, et al., 2009). The 14-item measure yields a total mental toughness score derived from 3 subscales: *confidence* (e.g., “I

have what it takes to perform well under pressure”), *constancy* (e.g., “*I take responsibility for setting myself challenging targets*”) and *control* (e.g., “*I get angry and frustrated when things do not go my way*” [reversed])). Participants rate each statement on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*).

Initial support for the factor structure, reliability, and validity of this measure was found in Sheard, et al. (2009). The measure possesses adequate internal consistency ($\alpha > .70$), convergent and discriminant validity (e.g., hardiness, optimism) and model fit (Gucciardi, 2012). Moreover, mental toughness was related to the behavioural outcome measure of actual competitive level achieved (Sheard, et al., 2009).

For the current study, a total score was calculated by taking the average scores across the three subsections for a grand SMTQ mental toughness index (all three subscales were correlated positively; $.15 \geq rs \leq .35$). Each subscale was also averaged separately to assess the specific qualities of mental toughness related to the measures of self-concept and sporting achievement.

Psychological Performance Inventory (PPI-A; Golby, et al., 2007). The PPI-A questionnaire calculates mental toughness derived from 4 subscales: *self-belief* (e.g. “*I lose my confidence very quickly*”), *determination* (e.g. “*The goals I’ve set for myself as a player keep me working hard*”), *positive cognition* (e.g. “*I am a positive thinker during competition*”), and *visualisation* (e.g. “*I visualise working through tough situations prior to competition*”), utilising a 1 (*almost always*) to 5 (*almost never*) scale. Absolute and incremental fit index benchmarks, satisfactory psychometric properties, and adequate reliability and convergent and discriminant validity for the PPI-A was demonstrated in Golby, et al. (2007).

As with the first measure, a composite PPI-A score (all four subscales were correlated positively; $.30 \geq rs \leq .50$) and individual scores for each subsection were calculated.

5.3.2.2. Self-Structure

Self-descriptive card sort. In the card-sorting task (Showers, 1992; adapted from Linville, 1987) participants were given 40 cards, each displaying a single self-attribute. Of the 40 self-attributes, 20 are positive (e.g., *giving, capable, communicative*) and 20 are negative (e.g., *hopeless, careless, inferior*). In the present design, participants were instructed to, “*Think of the different aspects of yourself/roles you play and then sort the cards into groups where each group describes an aspect of yourself or your life.*” They were asked to provide sports-related aspects or roles if possible. Participants could include as many or as few self-attributes as they chose in each self-aspect group. They were asked to only include attributes that they feel are self-descriptive; hence some attributes may be used in multiple groups, whereas others may be excluded completely. For more detail, see Showers & Kevlyn (1999).

Participants were asked to consider the different roles in their life and examples within and outside of sport were provided for clarity. Each participant then generated up to seven self-aspects and inserted them appropriately into an online format. The “card sort” followed, wherein participants inserted attributes (displayed in a list format) they deemed relevant to the self into their appropriate self-aspects. See Appendix 1 for an example card-sort from a participant in this study. This particular layout allowed the task to be performed in an easy-to-use form that maintained the standardised format and instructions used previously (e.g., Showers, 2002). The online questionnaire was piloted with twenty sports students, who also completed the face to face card sort task. Participants produced identical card-sorts for both formats ($r = 1.0$).

It should be noted that instructions were added to include sport related self-aspects in order to capture the most salient selves related to mental toughness. The evaluative organisation model, however, places limited importance on the actual groups participants

create and is instead a measure of the placement of positive and negative self-beliefs in those groups. Hence, selves need not be real, complete, or even accurate (cf. Ditzfeld & Showers, in press), as the primary interest is the cognitive-affective structure of the person (i.e., structural “styles”). Moreover, the inclusion of sport and non-sport aspects allows the measure to capture potential vulnerabilities that may be missed by including only one or the other (e.g., an elite athlete may overlook their frustration in failure when thinking about themselves overall as an athlete, but those tendencies emerge in other sports-unrelated self-aspects).

Evaluative organisation (*phi*). Compartmentalisation is scored by calculating a *phi*-coefficient (Cramer, 1974; Everitt, 1977) for each participant. Phi is based on a chi-square statistic in which the participant’s distribution of positive and negative self-attributes across self-aspects is compared to a distribution that is expected by chance. Phi scores range on a continuum from perfectly integrative (0) to perfectly compartmentalised (1.0). The expected frequencies are representative of a chance card sort distribution of positive and negative attributes. For example, if the entire card-sort contained 40% negative attributes, then a self-aspect containing 10 attributes would be expected to consist of 4 negative attributes and 6 positive (identical proportion to the overall % of positive versus negative characteristics). The observed frequencies are obtained from the card sort task. The chi-square statistic is computed using the observed and expected frequencies and is normalised by dividing by the total number of attributes present in the sort. This measure is independent of the number of self-aspects selected.

Differential importance (DI) and negativity (neg). When compartmentalisation is used to predict outcome measures such as self-esteem, the phi coefficient is moderated by indices of the overall positivity or negativity (neg) of the self-concept (e.g., Showers, 2002). As these

qualities may be important in predicting mental toughness, we included them in the present analyses.

DI is the measure of relative importance of a participant's positive and negative self-aspects (cf. Pelham & Swann, 1989). Following the card sort completion, participants rate the positivity, negativity, and importance of each self-aspect on a 7-point Likert scale. DI is the correlation between the perceived importance and the positivity or negativity (difference score) of each self-aspect, across all self-aspects. Scores on the DI measure range from -1 (negative aspects = most important) to 1 (positive aspects = most important).

Neg is calculated by taking the total number of negative self-attributes used in the card sort task and dividing that number by the total number of self-attributes used. Neg is a direct measure of the overall content of an individual's self-concept (Showers, et al., 1998), whereas DI measures the tendencies of individuals to strategically weight positive aspects as more important in order to maintain positive feelings toward the self (e.g., Pelham & Swann, 1989).

5.3.3. Procedure

Following ethical approval by the University Ethics Committee, participants logged onto the online site to provide informed consent and complete the study, taking roughly 30 minutes. The online questionnaire was emailed to local clubs in the North-East of England. After providing demographic details, participants completed the card-sort task, DI measures, PPI-A, and SMTQ, in that order. The questionnaire was made available online to individuals involved in sport clubs in the North Eastern region (including football, swimming, athletics, rugby, and cricket clubs) who were recruited via email for a period of six months.

5.4. RESULTS

As noted, measures of mental toughness require further validation (Crust, 2008), hence an initial analysis examined whether SMTQ and PPI-A scales measure separate elements of the multi-dimensional construct of mental toughness. The 3 SMTQ subscales and 4 PPI-A subscales shared low correlations with each other ($r_s \leq .30$), indicating that each subscale appears to measure distinct elements of mental toughness. The 7 separate scales were treated separately analysis, in addition to the SMTQ and PPI-A composites.

5.4.1. Analysis Sample

Ten participants were excluded from analyses involving compartmentalisation for having fewer than three self-aspect groups (1) or having only a single negative attribute (9). The exclusion of individuals with a single negative attribute is due to the *phi*-coefficient being sensitive to extreme fluctuations in such cases (cf. Showers & Kevlyn, 1999). Although this is a significant portion of the sample, the removal of these participants was necessary to prevent such fluctuations that would impact the final result. Therefore, the compartmentalisation analyses included the remaining 96 participants.

5.4.2. Regression Analyses: compartmentalization and mental Toughness

Hierarchical multiple regression analyses were used by regressing mental toughness scores onto measures of compartmentalisation (*phi*), neg, and DI. Hence, the main effect variables were entered on Step 1 (and zero-centred to test interactions on subsequent steps; Aiken & West, 1991). On Step 2, the three possible two-way interactions were entered. On Step 3, the three-way interaction was entered. The first set of focal analyses involved the

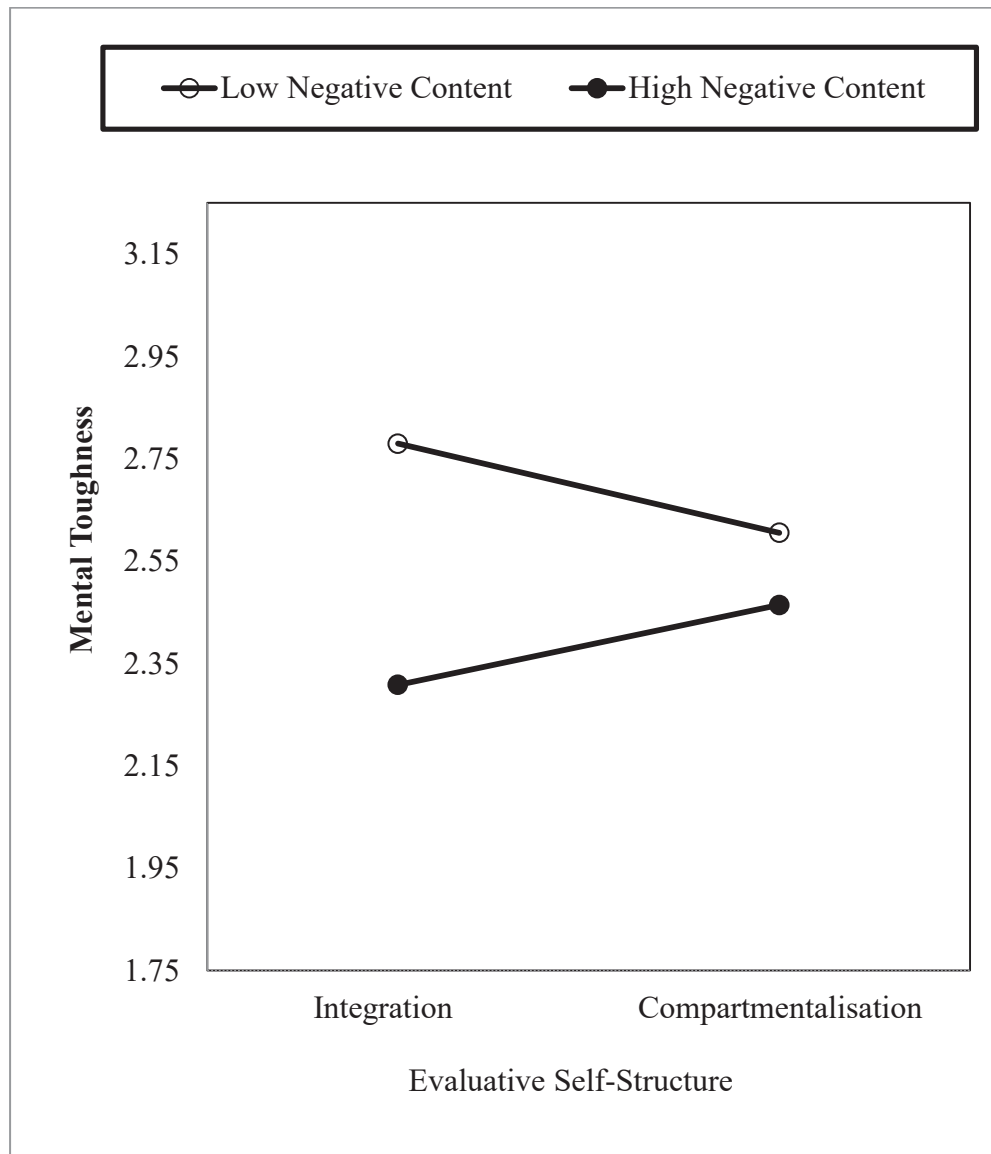
SMTQ measures, starting with the global score as the criterion, followed by its subscales.

The second set of analyses included the PPI-A measures in the same format as above.

5.4.3. SMTQ mental toughness

Global mental toughness. There was a significant main effect of neg, $\beta = -.31, p = .003$. A relatively negative self-concept was associated with low mental toughness. This main effect was qualified by a significant Phi x Neg interaction, $\beta = .27, p = .017$ (Figure 4.1). As predicted, people with positively integrative selves reported especially high mental toughness, particularly in comparison with people with negatively integrative selves, $t = -3.86, \beta = -.64, p < .001$ (simple slope analyses; Aiken & West, 1991). People with positively compartmentalised selves were slightly more mentally tough than people with negatively compartmentalised selves, $\beta = .18, t = 1.6, p = .12$. Comparing integrative versus compartmentalised self-structure, integratives reported marginally more mental toughness than compartmentalised individuals when the self-concept was relatively positive, $\beta = -.22, t = -1.92, p = .058$. In people with negative self-concepts, compartmentalisation was associated with slightly higher mental toughness, $t = 1.46, \beta = .34, p < .15$.

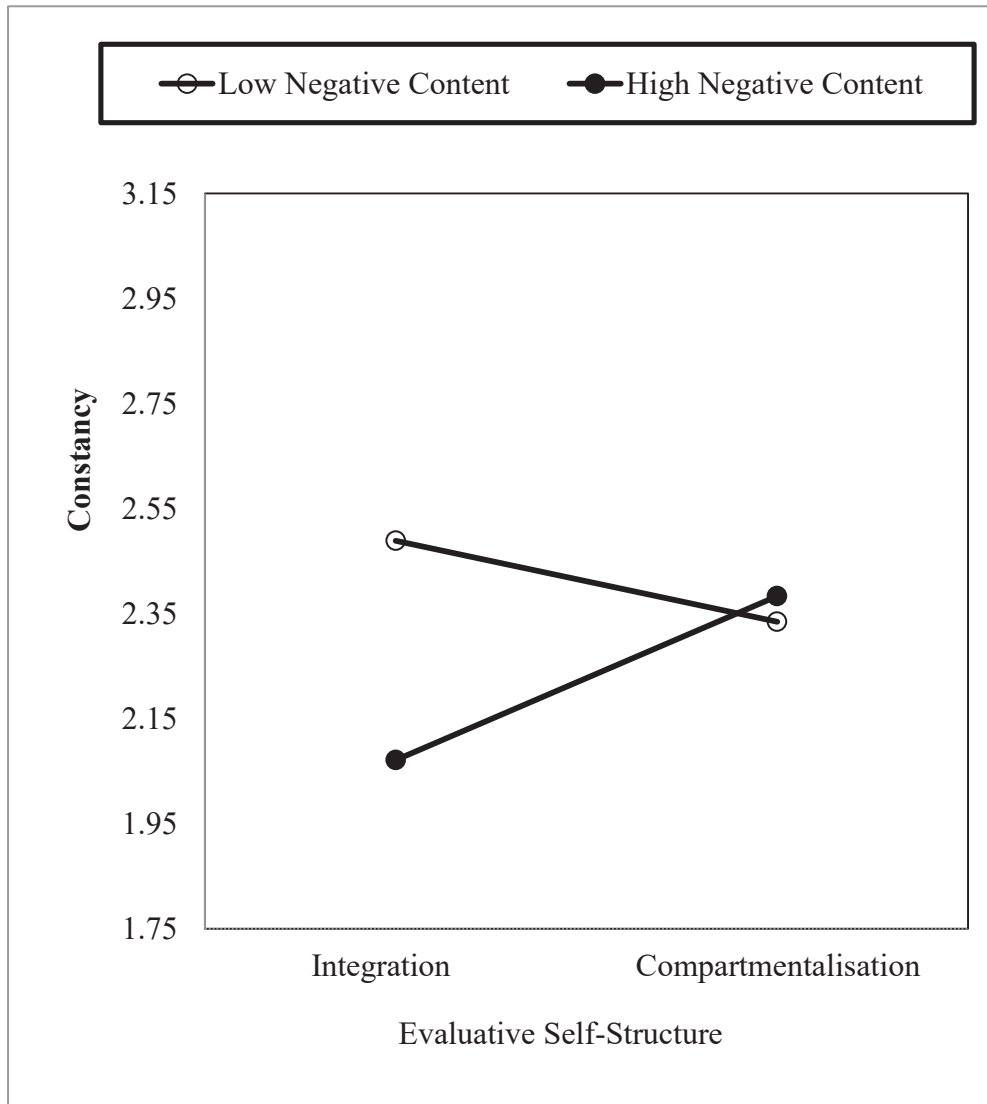
Figure 5.1.: Global mental toughness interactive effect.



Constancy. No significant main effects appeared, due in part to two significant interactions involving Phi x Neg, $\beta = .28, p < .02$, and Phi x DI, $\beta = -.23, p = .03$. This interactive effect is displayed in Figure 4.2. As with the composite measure, these interactions indicate that positive integratives (low neg, high DI) report substantially more constancy than do negative integratives (high neg, low DI), $\beta = -.39, t = -2.33, p < .03$ (simple

slope for neg when phi entered 1 *SD* below the mean). Positive and negative compartmentalisation was associated with moderate constancy.

Figure 5.2: Constancy interactive effect



Control. There was a significant main effect of neg, $\beta = -.31$, $p = .003$. People with negative self-concepts reported lower levels of control.

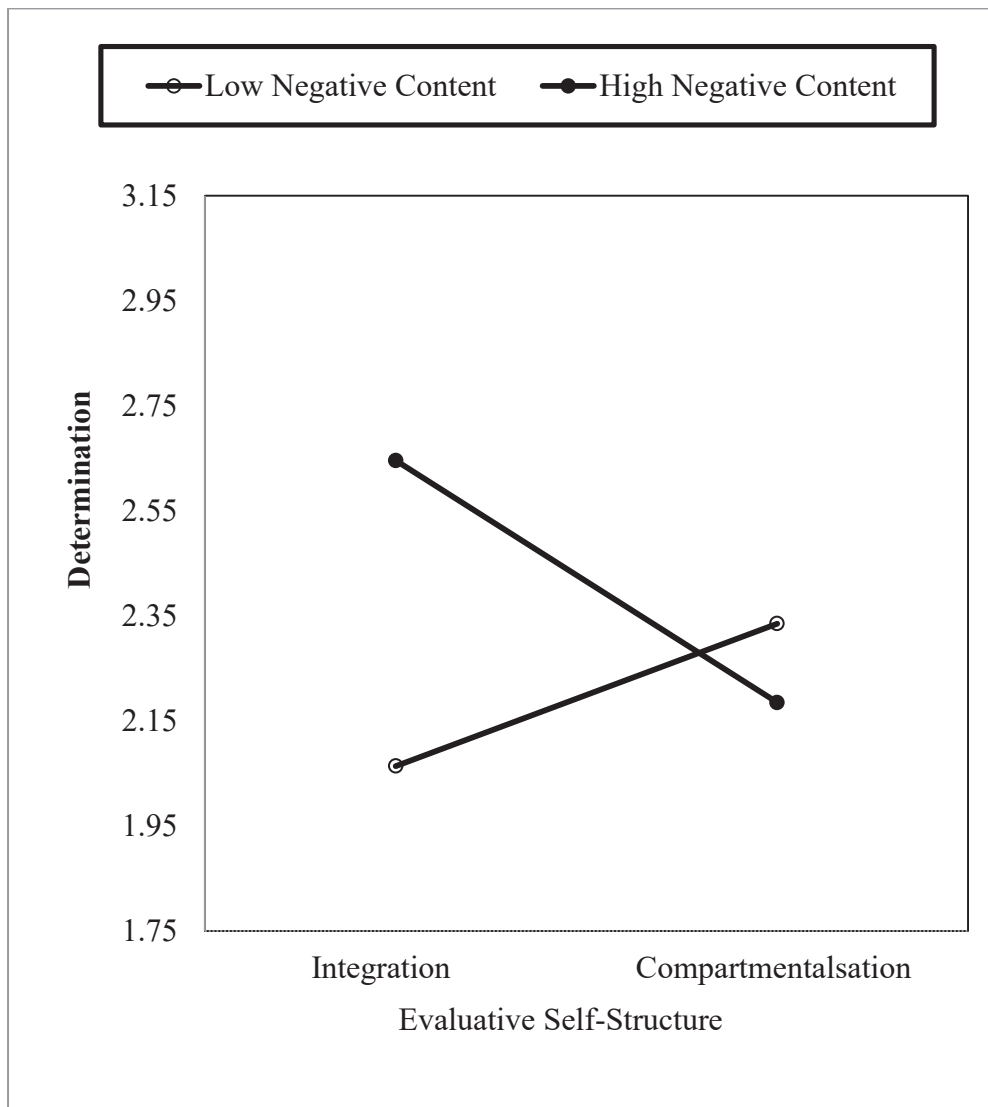
Confidence. There was significant main effect of neg, $\beta = -.22$, $p < .04$. People with relatively negative self-concepts were low in confidence.

5.4.4. PPI-A mental toughness

No main effects or interactions involving the evaluative self-organisation variables were significant for the global PPI-A score nor for most of its subscales.

Determination. There were no main effects for determination, but there was a Phi x Neg interaction, $\beta = -.25$, $p < .04$. This interactive effect is displayed in Figure 4.3. Contrary to SMTQ findings, negative integrative reported especially high determination. They were marginally more determined than positive integratives, $\beta = .35$, $t = 1.92$, $p < .06$. Positive and negative compartmentalisation was associated with moderate determination (statistically at the same level as positive integration).

Figure 5.3: Determination interactive effect



5.4.5. Mental Toughness and Self-Structure Across Sport Level

To test whether there were differences on the focal measures (SMTQ, PPI-A, self-structure measures) among individuals at different levels of sporting achievement, separate one-way ANOVAs with three levels of the independent variable (leisure/school, regional, national/international) were performed. Planned comparisons were run to compare each group separately.

SMTQ. There was a significant difference among the three levels of sporting achievement using the SMTQ global score, $F(2, 102) = 5.20, \eta^2 = .09, p = .007$. National and international

athletes ($M = 2.70$) reported significantly more mental toughness than athletes competing at school or leisure level ($M = 2.42$), $t(74) = 2.98$, $d = .69$, $p = .004$, but no more than those who compete in regional competition ($M = 2.58$), $t(54) = 1.25$, *ns*. Regional athletes reported marginally more mental toughness than recreational sports people, $t(76) = 1.88$, $d = .43$, $p < .07$.

Consistent with the global mental toughness measure, there was also a significant difference among the three competitive levels for the confidence subscale, $F(2, 102) = 10.16$, $\eta^2 = .17$, $p < .001$, and control subscale, $F(2, 102) = 4.43$, $\eta^2 = .07$, $p < .02$. International athletes ($M = 3.06$) reported more confidence than those who compete at school or leisure level ($M = 2.48$), $t(74) = 4.17$, $d = .97$, $p < .001$, and those who compete regionally ($M = 2.60$), $t(54) = 3.59$, $d = .98$, $p = .001$. There was no difference in confidence between school/leisure and regional athletes $t(76) = .90$, *ns*. International ($M = 2.87$) and regional athletes ($M = 2.83$) reported equal levels of control, $t(54) = .25$, *ns*; which were both significantly higher than school/leisure athletes ($M = 2.51$), $ts > 2.30$, $ds > .50$, $ps \leq .02$. There were no significant differences found among the three sporting levels for constancy in the ANOVA or planned comparison analyses.

PPI-A. There was no significant difference when testing among groups for this measure, $F(2, 102) = 2.18$, $p = .12$; however, planned comparisons showed that national and international athletes ($M = 2.68$) reported more PPI-A mental toughness than did school and leisure athletes ($M = 2.42$), $t(74) = 2.04$, $d = .47$, $p < .05$. Regional athletes ($M = 2.63$) did not differ significantly from either of the other two groups, $|t|s < 1.63$, $ps > .10$.

Among the PPI-A subscales, there was a significant difference among groups for self-belief, $F(2, 102) = 3.86$, $\eta^2 = .07$, $p < .03$. No other subscale produced significant differences ($ps > .35$). National and international athletes ($M = 3.02$) reported significantly higher self-

belief than did school and leisure athletes ($M = 2.45$), $t(74) = 2.89$, $d = .67$, $p = .005$; regional athletes ($M = 2.78$) did not differ significantly from other athletes, $|t|s < 1.35$ $ps \geq .19$.

Compartmentalisation, neg, and DI. No significant difference among the groups for evaluative compartmentalisation was found with the one-way ANOVA, $F(2, 93) = .32$, ns . Moreover, none of the groups differed significantly from another in the planned comparisons, $|t|s \leq .58$, $ps > .50$. However, further examination of the groups showed a marginally significant difference between international ($M = .68$) and national ($M = .38$) athletes on the compartmentalisation measure, $t(10.38) = 2.31$, $p = .06$, which led to assessing the groups separately. International athletes were more compartmentalised than were school and leisure athletes ($M = .44$), $t(55) = 2.10$, $d = .57$, $p = .04$, as well as regional athletes ($M = .43$), $t(31) = 2.15$, $d = .77$, $p = .04$.

There was a significant difference among athlete-level in regard to the proportion of negativity in self-concepts, $F(2, 93) = 6.27$, $p < .005$. National and international athletes had significantly less negative content ($M = .12$) than did school/leisure athletes ($M = .26$), $t(69) = -3.38$, $d = .88$, $p = .001$. Regional athletes ($M = .18$) had marginally less negative content than did school and leisure athletes, $t(72) = -1.84$, $d = .43$, $p = .07$. National/international athletes did not differ significantly from regional athletes, $t(45) = -1.58$, $p = .12$.

No significant differences among sport level were found for DI, $F(2, 93) = .74$, and $|t|s < 1.2$, all $ps > .20$.

5.5. DISCUSSION

The present study yielded evidence linking evaluative self-structures with different levels of mental toughness, and that both mental toughness and self-structure variables are related to level of sporting achievement. Across SMTQ measures, the proportion of negative self-content was associated negatively with mental toughness (control, confidence), and was

qualified by an interaction with evaluative self-structure for the constancy subscale. Overall, people with positively integrative self-structures reported being the most mentally tough, particularly in comparison to individuals who are negatively integrative.

Compartmentalisation, regardless of negative content, tended to have moderate levels of mental toughness. Lastly, in support of previous research, greater self-reported mental toughness was found in individuals at the highest level of sporting achievement, and national and international competitors reported the highest levels of mental toughness for the SMTQ composite (viz. confidence and control subscales) and the PPI-A self-belief subscale (Golby & Sheard, 2004; Kuan & Roy, 2007).

The study provides evidence for the convergent validity of the SMTQ with the evaluative self-concept measures. Measures of evaluative self-organisation (compartmentalisation, neg, and DI) are well-validated to be associated with emotion and self-regulation outcomes across a broad range of contexts (cf. Showers & Zeigler-Hill, 2012). The study supports the notion that mentally tough athletes tend to have positive self-concepts that are not particularly vulnerable to strong emotions. It is also worth noting that the amount of negative self-content and self-structure (ϕ) predicted mental toughness and sporting level of achievement better than did the differential importance, which generally is considered a measure of self-esteem (Pelham & Swann, 1989).

The finding that positive integratives have especially high levels of mental toughness is consistent with previous research linking this structure with resilience (cf. Showers, 2002). For example, positive-integratives may minimise self-doubt by activating positive self-qualities (*"I am capable"*) that maintain or increase confidence. Indeed, Ditzfeld and Showers (in press) report that positive integratives perceive their multiple selves as more authentic (i.e., *self-determined*; cf. Ryan & Deci, 2000), and have lower self-worth contingencies (cf. Crocker & Wolfe, 2001), than people with other self-structures. Taken

together, positive-integratives may be able to remain calm in the face of challenges, perhaps because their self-esteem is not contingent on performance (e.g., Zeigler-Hill & Showers, 2007).

Whereas positive-integration corresponds with high mental toughness, integration when one's self-concept is relatively negative appears to have the opposite effect. Showers, Zeigler-Hill & Limke (2006) suggest that, unlike positive-integratives, negative-integratives fail to buffer fully against the impact of their negative self-beliefs, which creates increased stress, negative mood, and lower self-esteem. By definition, these individuals should possess low levels of mental toughness. One possible source of their relative weakness stems from these individuals either not accessing, or sufficiently weighting positive self-beliefs. In fact, situations in which mentally tough individuals may thrive (e.g., the thrill of a challenge) seem aversive to negative-integratives (Ditzfeld & Showers, 2012a) suggesting that any high-arousal affective response may increase access to negative self-beliefs. Negative-integratives, however, reported the highest levels of determination (despite low ratings on constancy). Perhaps these individuals are highly determined to succeed, but when challenges arise, they become vulnerable to self-doubt. Determination was not strongly associated with sporting success.

Over most levels of sports competition, positive-integration may facilitate superior performance, with one possible exception. International athletes were disproportionately more compartmentalised than were people in lower levels of competition. In elite athletes, compartmentalisation may hold an advantage because these individuals' affective reactivity (Ditzfeld & Showers, *in press*) may place them "in the zone" (e.g., social facilitation; cf Zajonc, 1965). Hence, compartmentalisers may not be particularly mentally tough (e.g., they may respond to losing with extreme negative affect) but their superior athletic ability may come to the surface in pressure situations. Overall, positive integration appears advantageous

in sport for most individuals, because occasional failures seem inevitable across most levels of competition. However, compartmentalisation may benefit those whose successes far outweigh their failures.

The present study suggests SMTQ to be the superior measure of mental toughness than is PPI-A, as the composite and subscales of control and constancy were associated with higher sporting achievement. In particular, internationally and nationally competitive athletes self-reported greater levels of mental toughness than did school/leisure athletes and (to a lesser degree) regional athletes, which is consistent with previous research (Golby & Sheard, 2004). Moreover, the SMTQ showed consistent associations with self-structure, particularly in regard to the negativity of self-concept.

Importantly, the SMTQ composite proved to be a good predictor of sporting success, despite medium-to-small correlations among its subscales ($.15 \geq rs \leq .35$). It appears that only a relatively small group of people maintain high levels of control, constancy, *and* confidence (i.e., a latent mental toughness variable), namely those who are positively integrative. Results suggest that although possessing all three characteristics aids sporting success, scoring low on one or two of the subscales does not necessarily detract from good performance. One may have high confidence, yet low constancy, and still be mentally tough enough to succeed to some degree. Interestingly, despite the PPI-A showing stronger correlations among its subscales (i.e., greater internal consistency), neither the composite nor its subscales appeared to be measuring mental toughness quite as well as the SMTQ (as shown in its correlations with sporting level and self-structure). The main exception was the extremely high degree of self-belief found in international athletes.

The present study aimed to identify basic potential cognitive-affective differences that relate to mental toughness. Despite criticisms regarding the SMTQ and PPI-A measures

(Crust, 2008; Gucciardi, 2012), these are the only scales available that have attempted to capture mental toughness across different sports and levels of competition (Gucciardi, 2012). The current data provide evidence that elite athletes do self-report higher levels of mental toughness than do individuals who participate in lower levels of competition and that this scale, namely the SMTQ, is associated with a self-concept measure with a strong empirical history of predicting with self-regulation and self-esteem outcomes. Hence, mental toughness appears to be a general characteristic of a person, which probably pervades (but also extends beyond) the sporting domain (Clough et al., 2002). Future research may wish to address the limitation of current mental toughness measurements, particularly in refining the SMTQ measure. Due to the changeable nature of self-structure (i.e., shifts in structure occur in response to extreme live events; Showers, 2002), future studies may wish to track structural changes over time in relation to stressful occurrences, and assess their association with mental toughness.

This study provides evidence for the utility of an evaluative self-structure model (Showers, 2002). It suggests that these underlying cognitive-affective variations are related to the construct of mental toughness. Such a finding supports previous studies that have proposed that mental toughness incorporates several cognitive and emotional differences (Sheard, 2008). However, the study was cross-sectional in nature and therefore no detailed or causal inferences can be drawn and the longevity of the effects identified is unknown. Perhaps future research may wish to investigate differences in the self and their relationship with mental toughness, during a challenging period. This would be particularly welcomed as the extant literature is plagued with a 'positive bias', in that research has primarily focused upon the success related aspects of mental toughness and in sports performers who have experienced a good and successful career. Research that examines mental toughness

manifestation in a period of negativity would provide a more balanced perspective of the construct. As this research is relatively novel, a detailed qualitative insight into the psychological functioning of a sports performer might identify important avenues for future research to explore. In order to add validity to the findings, triangulating data from coaches, sport scientists, sport psychologists and the sport performer would present a detailed and phenomenological perspective of mental toughness. Furthermore, a longitudinal study that includes a variety of physiological (hormonal responses) and psychological measurements (psychometrics and semi-structured interviews) could advance our detailed understanding of mental toughness in different contexts.

This kind of detailed qualitative research is a welcome addition to mental toughness knowledge development and complements the predominantly quantitative studies that have been presented so far in this research quest. The extant literature has primarily sought to understand mental toughness through examining the responses from one group of individuals, i.e., sports performers or coaches. Therefore, combining physiological and psychological measurements and conducting measurements at several periods across a long period of time, would provide a novel insight into the attributes associated with mental toughness.

CHAPTER VI: PSYCHOLOGICAL PROFILING UTILISING COGNITIVE-AFFECTIVE, PHYSIOLOGICAL AND BEHAVIOURAL MARKERS

Research on mental toughness has primarily aimed to develop self report measures of the construct and has begun to demonstrate the utility of such measurements in an applied context (Sheard & Golby, 2007). Indeed, self report measures are useful in that they are easy to administer and provide an objective score from which normative comparisons can be made. However, as a stand alone measurement, they can be susceptible to social desirability effects and their reliability is questionable. Therefore, a primary aim of this thesis was to develop and provide support for the use of various markers of mental toughness. The important markers that were established by the previous studies in this thesis were utilized in an applied setting. A case participant was recruited to demonstrate the usefulness of these markers when profiling competitive sports people in the initial stage of a consultancy process. A longitudinal, mixed method assessment of the participants was conducted to explore the psychological profile of an adolescent athlete who demonstrated over-training behaviours. The resulting holistic profile included physiological, cognitive and behavioural measures. The usefulness of these markers is discussed along with the benefits of profiling a sports person using several markers that examine different manifestations of mental toughness.

6.2. INTRODUCTION

Sport performers, who participate in their chosen sport regularly, generally develop a strong and ingrained athletic identity. Athletic identity can be defined as the cognitive structure which processes self-related information (Brewer, Van Raalte & Linder, 1993). The sheer amount of time dedicated to training/competing in sport means that a sports person's athletic identity is accessed regularly and the perceived importance of that role is generally high (Groff & Zabriskie, 2006; Curry, 1993). However, development of knowledge in this area has been restricted as more subtle, and novel measures of self-structure that are examined in other psychology domains have not yet been applied to sport (such as the model utilised in Study III).

Although a strong athletic identity might be related to increased motivation and dedication to the athletic role, when that identity is threatened (perhaps through injury) this may result in the individual experiencing an intense threat to their sense of self (unidimensional identity), negative mood (Nipper & Smith, 2008) and emotional difficulties (Miller & Hoffman, 2009). Coakley (1992) argues that athletes with restricted development in other areas outside of sport (such as academia and socially) can feel entrapped by their athletic identity and may experience a decreased sense of perceived control. However, it must be noted that there is little empirical evidence to support this theoretical claim. Perceived control is defined as the belief that one has control over one's life outcomes (Carver & Scheier, 2002) and is an integral part of the intuitively appealing construct, mental toughness (Crust & Clough, 2005). As previously noted, the multifaceted construct includes various behavioural, cognitive and physiological factors that collectively allow an individual to remain in pursuit of their goals (Gucciardi, et al., 2008).

The physical demands of training and succeeding in high level sport arguably lead to the prevalence of injury among sport performers (Richard, Andersen & Morris, 2008). During a period of injury, many athletes experience psychological and emotional barriers. As all competitive athletes are likely to experience a period of injury at some point during their career, it is important to understand the association between psychological constructs and rehabilitation from injury in sport. Such an understanding of injury rehabilitation and individual differences such as mental toughness will allow for appropriate interventions and support to be prescribed. In order to appropriately direct research in this area it is important to present some of the psychological impacts or changes associated with sports injury. Indeed, research has already suggested that sports people have a prominent and important athletic identity that can become threatened during injury periods (Green, 2001).

A detailed insight into the self-structure, psychophysiological responses to stress and mental toughness may provide a holistic profile of sports people.

Furthermore, self-structure is arguably a dynamic and shifting formation (Showers, 2002) and therefore the changeability of ‘the self’ across the rehabilitation period might provide a more holistic insight into the psychological change association with injury. This research will also extend the cognitive examination of mental toughness that was initiated in Study III.

Indeed, the holistic consideration of rehabilitation processes within the current study includes physiological measures of psychological and biological adaptation, i.e., cortisol levels. The stress hormone cortisol has been utilised as a marker of overtraining, stress and inability to cope with the demands of sport, i.e., burnout (Zanstra, Schellekens, Schaap & Kooistra, 2006). Therefore, in the current case, where overtraining and burnout are possibilities (injury), such a physiological marker provides an holistic perspective of the phenomenon. Another important feature, when considering injury, is that of ‘the self’, the

self-structure model (Showers, 2002) presented in Study III has been shown to be important when considering mental toughness, and therefore could be a useful model in the present study.

The case study design allows a relevant problem to be viewed from varying, detailed perspectives and methods, resulting in a rich, holistic and meticulous perspective of mental toughness (Velde, Jansen & Anderson, 2004). Utilising both qualitative and quantitative data collection methods, a detailed and longitudinal perspective of the psychological profile of an adolescent athlete is provided. This allows for a valuable and novel insight into the psychological profiles of athletes prior to breaking through to the elite ranks of sport.

Adolescent athletes present especially valuable cases, in that they must balance their growth, physical and psychological development changes and an increasing pressure to perform, as they progress through the ranks in their competitive sport. Therefore, developing appropriate measures (or markers) for psychological constructs is useful to understand their developing psychological traits and skills. Moreover, an injury period provides an ideal contextual setting in which to address an adolescent's response to stress and adversity.

The case studies presented here was designed to demonstrate the utility of the proposed mental toughness markers that were developed in chapters III-V. It is hoped that the mixed method assessments provide sufficient detail to show how selecting appropriate markers and conducting a longitudinal assessment can provide sport practitioners with invaluable, rich information about sports people. The inclusion of various markers of mental toughness allows for a more complete profile to be developed which will eventually lead to specifically designed, individually tailored intervention programmes. Two inherently

different case participants were recruited in order to demonstrate the feasibility of these mental toughness markers in different roles and contexts.

6.3. METHOD

6.3.1. Participant

The organisational scheme proposed by Vealey & Garner-Holman (1998) depicts four broad domains that provide a base for assessment and evaluation of sportspersons, three of which are used to structure the current study, as the fourth was deemed inappropriate for the current case example. These are (a) individual characteristics of the athletes (gender, country, age, goals); (b) contextual characteristics (coaches, colleagues/team-mates, time of competitive season); (c) characteristics of the consultant (competence, philosophy and style).

6.3.1.1. Individual characteristics. The participant was identified as Jasmine, (19 years old at the beginning of the study) a potential future international 1500m track athlete. Jasmine had been involved in athletics for the last six years, with two years at the current level. Her highest achievement to date was her second placing in the English Schools U19 category; this achievement was prior to 12 + months of injury that followed. Jasmine was extremely ambitious; she hoped to become a full time international athlete within the next four years. At the time of assessment, Jasmine had suffered a stress fracture in the tibia that was diagnosed as a result of overtraining (medical diagnosis).

6.3.1.2. Contextual characteristics. Jasmine lived at home with her parents and was studying towards a degree in Sports Science. She received financial and athletic support from the elite athlete bursary scheme at her University. The bursary scheme enabled Jasmine to receive support from several strength and conditioning experts, who had contact, three times per

week, with Jasmine and monitored her physical abilities closely. Prior to contacting the researcher, Jasmine had received no support/advice from a psychological perspective.

7.3.2.3. *Organisational culture*

At her level of athletic competition, the Diamond League tour and English School's Championships are the most prestigious national competitions. Jasmine's highest achievement to date was 2nd placing in the 1500m at the previous years' English School's Championships. Jasmine competed in the U19 category, following success at this level she would then move on to the U21 category and then into the senior competitive ranks.

6.3.2. Assessment and interview process

The assessment process was conducted over a year (an entire athletic season) long period and five assessment periods were undertaken at several time points (specifically, an initial assessment, three months, six months, nine months and twelve months). Data collection included semi-structured, qualitative interviewing (Zimmerman, 1994), along with quantitative psychometric assessment. Moreover, the researcher conducted several observations during weight training sessions and physiological measurements prior to and after competition and training, i.e., cortisol levels. The semi-structured interviews included open-ended questions that were designed to elicit novel ideas (Smith & Sparkes, 2012) about mental toughness, experiences during injury (behavioural, affective and cognitive factors) and perceptions of injury rehabilitation. Self-talk diaries were also completed weekly, with particular focus on perceived emotions and cognitions in rest periods, before and after

training and competition, and in response to major changes or injury rehabilitation advice (development of the injury).

6.3.4. Observations of participant behavior during training sessions

Five separate weight training sessions with two different coaches/sports experts were attended at one month, three months, six months, nine months and twelve months (by two independent researchers). The training sessions took place at the University gymnasium.

6.3.5. Measures

All measures were administered at four stages throughout the year long assessment period, 3 months apart. Throughout the year, Jasmine was unable to train fully and had ongoing injury problems (stress fractures). Time 1: Jasmine had just discovered her stress fracture and was in a complete break from training (lasting two weeks). Time 2: Jasmine was beginning to increase her training load. Time 3: Jasmine was back to full training and competed in two lower level races. Time 4: Jasmine suffered another stress fracture (worse than the last) and had to break from training.

6.3.5.1. Mental toughness measures

The alternative Psychological Performance Inventory (PPI-A, Golby, et al., 2007), was utilised to measure mental toughness. The questionnaire obtains an overall toughness score, and 4 sub scale scores: self-belief, determination, positive cognition and visualisation. Scoring utilises a five-point Likert scale, ranging from ‘almost always’ to ‘almost never’. The inventory possesses satisfactory psychometric properties, with adequate reliability and convergent and discriminant validity (Golby, et al., 2007).

The Sport Mental Toughness Questionnaire (SMTQ: Sheard, et al., 2009) was used as a secondary measure of mental toughness. The measure yields a total mental toughness figure, and 3 subscale scores; confidence, constancy and control. There is preliminary support for the factor structure, reliability and validity of the measure (Sheard, et al., 2009); the internal consistency of factors was found to be good, with all alpha coefficients above 0.7. Support for discriminant validity is provided due to the low to moderate correlations identified between distinct concepts (e.g., hardiness and optimism: Crust & Swann, 2011).

6.3.5.2. Profile of Mood States

McNair, Lorr & Droppleman (1971) developed the Profile of Mood States (POMS) test. The POMS test consists of 65 adjectives describing mood, rated on a five-point Likert scale ranging from 0 (not at all) to 4 (extremely). The POMS is divided into 6 factors describing six mood dimensions: tension, depression, anger, fatigue, confusion, and vigour. The raw scores for the subscales range from: confusion: 0-28, vigour: 0-32, fatigue: 0-28, depression: 0-60, anger: 0-48, tension: 0-36. Test re-test reliability coefficients reported for each subscale were: depression ($r = .74$), tension ($r = .70$), anger ($r = .71$), confusion ($r = .68$), fatigue ($r = .66$), and vigour ($r = .65$) (McNair, et al., 1971). Measures of internal consistency have been reported to be between 0.85 and 0.95 depending upon the subscale (McNair, et al., 1971).

6.3.5.3. Athletic identity measure

The Athletic Identity Measurement Scale (AIMS: Brewer, et al., 1993) was selected to measure the strength and exclusivity of identification to the athlete role. The AIMS consists of 10 items scored on a 7-point Likert-type scale, ranging from “strongly disagree” to “strongly agree.” Higher scores reflect greater identification with the athlete role. Internal

consistency has been reported to be high with an alpha coefficient of .93. Test-retest reliability was reported as .89 (Brewer, et al., 1993). Evidence also supports the measures construct validity (Brewer, et al, 1993).

6.3.5.4. Self-Descriptive Card Sort

In the card sorting task (Showers, 1992; adapted from Linville, 1987), participants are given 40 cards, each displaying a single self-attribute. Of the 40 self-attributes, 20 are positive (e.g., giving, capable, communicative) and 20 are negative (e.g., hopeless, careless, inferior). In the present design, participants are instructed to, “Think of the different aspects of yourself/roles you play and then sort the cards into groups where each group describes an aspect of yourself or your life.” They are asked to provide sports-related aspects or roles if possible. Participants could include as many or as few self-attributes as they choose in each self-aspect group; they are asked only to include the ones they feel are self-descriptive; hence some attributes may be used in multiple groups, whereas others may be excluded completely. See Showers and Kevlyn (1999) for more details.

Compartmentalisation is scored by calculating a phi-coefficient (Cramer, 1974; Everitt, 1977) for each participant. Phi is based on a chi-square statistic in which the participant’s distribution of positive and negative self-attributes across self-aspects is compared to a distribution that is expected by chance. Phi scores range on a continuum from perfectly integrative (0) to perfectly compartmentalised (1).

Differential importance (DI) and negativity (neg): Commonly, when compartmentalisation is used to predict outcome measures such as self-esteem, the phi coefficient is moderated by indices of the overall positivity or negativity of the self-concept

(e.g., Showers, 2002). As these qualities may be important in predicting mental toughness, they are included in the present analyses.

DI is the measure of relative importance of a participant's positive and negative self-aspects (cf. Pelham & Swann, 1989). After card sort completion, participants rate the positivity, negativity, and importance of each self-aspect on a 7-point Likert scale. DI is the correlation between the perceived importance and the positivity or negativity (difference score) of each self-aspect, across all self-aspects. Scores on this measure range from -1 (Important negative aspects) to 1 (Important positive aspects).

Neg is calculated by taking the total number of negative self-attributes used in the card sort task and dividing that number by the total number of self-attributes used. Neg is a direct measure of the overall content of an individual's self-concept (Showers, et al., 1998), whereas DI measures the tendencies of individuals to strategically weight positive aspects as more important, in order to maintain positive feelings toward the self (Pelham & Swann, 1989).

6.3.5.5. Anxiety measure

CSAI-2R - Revised Competitive State Anxiety Inventory-2 (Cox, et al., 2003). The CSAI-2R is a 17-item scale that measures cognitive state anxiety (5 items), somatic state anxiety (7 items) and self-confidence (5 items) in a competitive setting. Respondents rate their feelings before competition (e.g., "*I feel jittery*", "*I am concerned about losing*") on a scale anchored by 1 = not at all and 4 = very much so. Furthermore, respondents are required to report the direction interpretation, i.e., how positive or negative they perceive their anxiety impacts upon performance, on a scale from -3 very debilitating to +3 very facilitative.

Subscale scores are calculated by summing items in each subscale, dividing by the number of items, and multiplying by 10. Score range is 10 – 40 for each subscale. The factorial validity of the CSAI-2R was previously established by Cox, et al., (2003) using confirmatory factor analysis (CFA) on data from 331 athletes, which showed a good fit of the hypothesised measurement model to the data (CFI = .95, NNFI = .94, RMSEA = .054).

6.3.5.6. Motivation

SMS-6 – Revised Sport motivation scale-6 (Mallet, et al., 2007). The SMS-6 is a 24-item scale that measures seven different forms of motivation, reflecting varying degrees of self-determination (Deci & Ryan, 1985). Participants are required to answer the question “*Why do you participate in your sport?*” with given responses such as “*Because it allows me to be well regarded by people that I know*” on a 7- point scale anchored by 1 = does not correspond at all and 7 = corresponds exactly.

6.3.5.7. Resilience

Academic resilience scale (Martin & Marsh, 2006). The academic resilience scale was adapted to suit sport specific settings. Participants were required to respond to 6 items, such as “*I don’t let a bad swim/performance affect my confidence*” anchored by a 7 point Likert scale ranging from 1 = strongly disagree to 7 = strongly agree.

6.3.5.8. Grit

Grit is defined as perseverance and passion for long-term goals measure (Duckworth, et al., 2007). The Grit scale is a 12 item measure, with subscales of consistency of interest (6

items) and perseverance and effort (6 items). Respondents rate each statement on a 6 point Likert scale, ranging from 1-very much like me, to 5- not like me at all.

6.3.5.9. Cortisol

To obtain the unbound serum levels of cortisol, saliva samples were collected exactly one week prior to the measured competition or training session, ten minutes before competing/training, and at one and four hour intervals following cessation of the race or session. Saliva sampling is an accurate measure of serum levels; correlations between the two values are highly significant; $r(47) = 0.91$, $p < 0.0001$. The participant was given precise instructions to chew on the salivette swab for sixty seconds, place it into the plastic tube and ensure it was sealed correctly. The participant also refrained from consuming any food or caffeine for up to one hour prior to saliva sampling. Samples were refrigerated at -200°C at a laboratory, in preparation for immunoassay. The intra-assay variability is estimated at 6.0%. Cortisol measurements were taken at a training session, 10 weeks following the initial injury and at a low level competition meet 8 months into the assessment period when the participant demonstrated partial physical recovery from injury.

7.3.4.1. Assessment

Four separate semi-structured interviews were conducted with Jasmine. The first occurred at the time of injury (immediately following diagnosis). The second interview occurred two months later (during a period of recovery training), the third interview occurred a further two months later (again a period of recovery) and the fourth occurred when the injury had returned (stress fracture to the tibia).

The entire assessment period for John, involved six one hour researcher-participant semi-structured interviews. Sessions occurred roughly every month at a North Eastern University. The interviews typically took place on Tuesday, after John had refereed a match on the previous Sunday.

Analysis

The analysis involved several systematic stages. Initially the transcripts were read repeatedly and notes were taken regarding key phrases, connections between aspects of the transcripts and initial interpretations. These notes were then condensed to produce themes. A constant process of ensuring the themes reflected the data, rather than a previous assumption based upon existing literature was carried out. Following this, the existing theoretical frameworks were consulted ensuring that the analysis was informed by theory but not driven by it. We acknowledge the subjective nature of the research, however steps were taken to ensure validity and direct quotations are provided to demonstrate the persuasiveness of the analysis. A process of bracketing (separating the authors' preconceptions and assumptions about mental toughness from the actual data) was employed to increase validity (Giorgi, 1970; Nesti, 2004) and two independent researchers conducted the analysis separately. Any discrepancies were discussed by the researchers until a final consensus was reached. A comparison of the accounts of the participant and the match assessor's reports also allowed for a useful comparison of two idiosyncratic perspectives of the same performance. A reflexive journal of the interview process was kept throughout.

6.4. RESULTS

Psychological profile

NB: Period 1: Onset of injury (crisis point: no training); Period 2: Partial training; Period 3: Following competition; Period 4: Injury crisis.

Table 6.1: Mental toughness

Total mental toughness (PPI-A)	1	2	3	4	Total mental toughness (SMTQ)	1	2	3	4
Self belief	8	10	11	7	Confidence	12	11	15	10
Determination	13	13	12	13	Constancy	14	13	14	14
Positive cognition	8	7	6	8	Control	7	9	9	6
Visualisation	8	9	10	8					

Qualitative interview:

When Jasmine was asked to describe what mental toughness meant to her, the description she provided primarily related to pushing pain barriers in training and competition:

Being mentally tough means smashing everything you do [sic] I think they would be super confident in competition and know they're going to win and smash everything they do in training [sic] showing that you really want it (success) and never giving up.

I won't let anyone tell me I won't make it, I will one day [sic] I will train through anything, through any pain, if it gets me a gold medal.

However, during the observation training sessions, Jasmine demonstrated a passive (and coachable) approach to training, she perceived that external sources controlled her behavior:

I feel helpless and useless [sic] When do I have to do this set? [sic] Do you want me to do that?

I don't trust myself to decide on my training [sic] They have to be in control as I'd just push myself too much and too hard [sic] I can't help trying to smash everything and beat everyone".

Emotional control:

I get really angry, frustrated and annoyed when I can't train, I can't help it [sic] I just end up being a nightmare to be around really, angry and upset'

Can I lift heavier today? Go on [sic] Can't I lift a bit more, please? [sic] What are we doing today?

Jasmine also reported introjected regulation tendencies, specifically the internalization of sporting ethics that suggest athletes must train consistently hard in order to be successful.

I'm so angry and annoyed when i can't train, I can't help it

I'm horrible to be around (due to her low mood), but I'll be fine when I'm training [sic] I need to train to be happy and calm; otherwise I'm an angry mess [sic] My parents say I'm a nightmare to be around as I'm just so angry and depressed all of the time.

Jasmine's confidence was somewhat tenuous throughout the assessment period, which was confirmed by her quantitative self report score and interview responses:

I feel confident after training if I'm running faster than the person next to me and [sic] It makes me feel good to beat the guys at lifting weights [sic] But if they do better than me in that session, it knocks me a bit, I don't feel good about it.

I don't deserve to be on the elite scheme, I haven't even raced [sic] I feel helpless and useless [sic] I'm no good at anything apart from running.

Table 6.2: Physiological measure: cortisol levels

Rest – one day before weights session.	Pre- weights (15 minutes)	Post- weights (1 hour)	Post- weights (4 hours)	Rest – one week pre- race	Pre-race (15 minutes)	Post- race (1 hours)	Post- race (4 hours)
0.437	0.482	0.467	0.478	0.512	0.488	0.466	0.491

Table 6.3: Resilience, Perseverance and Consistency scores.

Time	Resilience	Perseverance	Consistency
1	38	28	26
2	36	26	25
3	37	27	26
4	38	27	27

Table 6.4: Evaluative self-structure

Time	Phi (Compartmentalisation score)	DI (Differential importance score)	Athletic identity score
1	1.0	-0.82	67
2	0.88	-0.45	66
3	0.95	0.25	67
4	0.75	-0.9	67

Qualitative interviews:

Jasmine's qualitative interviews revealed a restricted, unidimensional identity and a basic philosophy of training.

For example, when asked who Jasmine felt she was, in terms of her roles and attributes she stated:

I'm a runner and that's it (Page 7, line 98).

I was just good at it [running] I suppose [sic] I'm no good at anything else [sic] My friends are all in athletics, I don't get time to spend with anyone else [sic] All I care about and think about is running, that's what I want to be successful at [sic] I'm the one who smashes everything in training, they all know (coaches/sport scientists) that's what I'm like, I suppose that's like my thing. (Page 7, line 106).

When Jasmine spoke about her motivation to take part in athletics, she stated that attaining successful outcomes were most important and she enjoyed the prestige of the label 'athlete':

I just want to win and be successful [sic] I like being called an athlete and believing that I am one. (Page 3, line 42).

Jasmine's roles were primarily involved in athletics

I don't have time for social activities but it doesn't bother me because this is what I have to do to be successful in running, I'm happy with just my training [sic] if my running is going well, I'm happy [sic] I don't know what I'll do when I stop running, I'll think about that if it comes. (Page 5, line 78).

When discussing an ideal, mentally tough performer, Jasmine stated:

You just have to put the miles in [sic] No pain, no gain [sic] You've just got to smash everything you do, that's the sign of a tough athlete. (Page 4, line 54).

Table 6.5: POMS

	Time 1	2	3	4
Depression	36	24	22	34
Anger	42	28	30	44
Tension	32	28	28	36
Fatigue	18	16	22	20
Confusion	8	12	6	12
Vigour	10	16	22	8

Qualitative interviews:

Jasmine's body language during observation sessions was very negative during time periods 1 (initial injury) and 4 (re-injury): Frustrated expression/grimacing. Head down and failure to make eye contact with the trainer.

For god's sake! [sic] I can't do this [sic] Look, I'm just weak now, that's a pathetic (amount of) weight (Page 8, line 20).

Body language: Aggressive and angry tone.

That was terrible, I'm so weak [sic] I'm sick of this, I can't do it [sic] what's going wrong?. (Page 8, line 42).

6.5. DISCUSSION

This chapter aimed to provide a longitudinal, detailed insight into the psychological profiles of a sports person, in order to demonstrate the utility of selected mental toughness markers (from studies I-III). The case study participant was an adolescent, pre-elite athlete experiencing a prolonged period of injury. This was to demonstrate how the proposed markers (cognitive, physiological and behavioural) can be used to explore the psychological profiles of athletes. The psychological profile will be discussed, with particular reference to the usefulness of the selected markers and measurements. Finally, suggestions for sport practitioners in using these markers are provided.

The participant was identified as Jasmine. Both qualitative interviews and the athletic identity measures revealed that Jasmine was solely invested in her athletic role, had expectations to become professional and elite and therefore, when such a prospect was

threatened; (by injury) she struggled to find appropriate resources to cope. Jasmine also reported a relentless desire to succeed and a tunnel vision focus and stubbornness. Perhaps, the characteristics that lead to mentally tough athletes succeeding, i.e., persistence and maintaining consistency in their tough approach to training (high pain threshold), may also be counterintuitive during periods of injury. The case example also highlights the importance of considering athletes' overall profiles of mental toughness, rather than a global measure alone.

Jasmine consistently self-reported high levels of determination, consistency and resilience. However, she scored relatively lower on the characteristics of perceived control and confidence, which supports previous research assessing the associated psychological characteristics of athletes with strong athletic identities and their responses to injury (Hofer, Busch & Kartner, 2011). Jasmine was relentlessly determined and consistent with her training and dedication to the athletic role, despite the inevitability of injury recurrence.

Behavioural (observations) and cognitive markers (evaluative self structure), within the assessment period indicated a lack of cognitive and emotional control and self-confidence. Jasmine also mistrusted her perceptions associated with training load (she believed she would overtrain) and thus, the desirable state of autonomy during a period of injury was not perceived as achievable. She experienced feelings of guilt and anxiety (qualitatively) when she could not train and reported a high level of introjected regulation motivation (SMS-6 score). This particular drive refers to the internalisation of the expectations and motivations of significant others, e.g., coaches and parents (Mallet, et al., 2007). Jasmine experienced a sense of '*needing to train*' in order to avoid cognitions surrounding guilt, anxiety and frustration (Wilson & Rodgers, 2004).

Jasmine's physiological and psychological profile was consistent with overtraining outcomes, i.e., burnout (ref). Indicative of overtraining, Jasmine had a stress fracture injury

(Kreider & Fry, 1998) and reduced peripheral and central physiological activation, i.e., blunted cortisol response (Maso, Lac, Filaire, Michaux & Robert, 2004) brought about by stressful events (an inability to respond sufficiently to stress), a lack of vitality, vigour and increased depression/fatigue. Jasmine's cortisol results imply a degree of burnout; her concentration of cortisol rose only slightly from basal level, to prior competition. This would suggest that Jasmine had triggered her stress response repeatedly (possibly due to her constant battle to achieve) and therefore the negative feedback loop may have become overstimulated and therefore damaged (Fries, Hesse, Hellhammer & Hellhammer, 2005). It therefore appears that Jasmine is unable to physiologically respond appropriately to stressors and be deemed to lack physiological toughness (her cortisol levels are constantly relatively low).

In terms of the cognitive measures, Ditzfeld and Showers' (2011) model of evaluative self-structure revealed her cognitive-affective profile. Previous research had suggested that integratives are more cognitively based and realistic, i.e., they view themselves as equally positive and negative across all self-roles (see chapter IV). Compartmentalised people (Jasmine was perfectly compartmentalised – $\Phi=1.0$) are supposedly driven by affect and this is usually beneficial for performance in times of positivity (extreme positive affect) but may leave the individual susceptible to negative affect in times of difficulty, e.g., periods of injury (Jasmine reported a negative compartmentalised self-structure, $DI = -0.82$). In line with this hypothesis it could be that compartmentalised individuals are less cognitively rational in terms of their perceptions of personal limitations than integrative people, because of their desire to experience positive affect. It appears that compartmentalisation may lead to negative outcomes, such as low perceived control and confidence, if an athlete experiences a consistent physical injury. This makes theoretical sense, if the most important, central athletic

identity becomes thwarted by injury, this role is then perceived as being wholly negative, yet still important, and this results in a reduction in self-confidence and perceived control over one's life. Indeed, this proposal is merely speculative at this stage in research. Such a proposal conforms to Showers' (2002) initial work on the evaluative organisation model that suggests that individuals with varying, complex roles are more likely to be resilient and emotionally stable. Jasmine was either uniformly negative at times when she was not successful in running, or uniformly positive (extreme positive affect) when she perceived her running as successful. Jasmine also experienced negative affect with consistently high levels of depression (40: POMS) anger (42: POMS) and helplessness (Brewer, 1998). These feelings were consistent throughout the assessment period (Jasmine was assessed at four time points), with slight variations occurring when training load or recovery altered. Specifically, Jasmine's mood and emotional state were directly dependent upon her perception of training load and severity of injury.

Recommendations to support of Jasmine's recovery could be drawn from this holistic profiling process. Jasmines physiological, cognitive-affective and behavioural functioning (both observed and self-reported) were assessed and that suggested that she possessed some attributes that are necessary for success in sport, e.g., determination, persistence, focus and will to win. However, she was lacking in terms of her physiological toughness (ability to respond appropriately to stressors), self confidence and emotional and cognitive control. Moreover, her cognitive profile possibly detracts from developing mental toughness. Jasmine was wholly invested in the athletic role and experienced extreme negative affect when that role was thwarted.

CHAPTER VIII: DISCUSSION

8.1. RESTATEMENT OF PURPOSE

Sport provides an opportunity for countries to showcase national talent and provides one of the few acceptable social status battles in society. The standard of performance is increasing in order to achieve prestige and sport performers worldwide are striving for an advantage over their competitors. Advances in sport science knowledge have contributed to the superior physiological conditioning of sport persons over recent decades. However, even those with the best physiological foundations and advice can fail to enter into elite sport. One explanation for these performance anomalies is that psychological factors play an important role in sport. It appears that those with apparent weaknesses in technical and physical abilities are able to compensate with relentless desires to achieve determination, commitment and an absolute belief in their abilities. It is therefore understandable that sports people have rated psychological attributes as the most important contributor to success (Gould, et al., 2002).

Performance in sport has been shown to involve many consistent demands and the competitive nature provides a valuable context in which to assess psychological constructs. An inspection of the existing literature in this area suggests that these demands may be physical, physiological, psychological and sociological in nature. Not all of these factors were assessed here, but they are important to consider when grounding the current research in the wider context of sport knowledge. Such demands may include pressures to perform consistently and in line with one's potential, physiological and physical exertion

(overstretching) and social sacrifice. In order to understand how specific performers are able to effectively manage the demands of their sport and demonstrate performance excellence, a consideration of the psychological factors that underpin sporting success remains an important avenue for research.

As noted in Chapter I, the most commonly reported psychological construct by coaches and athletes that holds importance in the sporting arena, is mental toughness (Gould, et al., 2002). Initial research had begun to accurately describe the construct, with precise definitions emerging more recently from theoretically and methodologically sound research (Gucciardi, et al., 2009; Coultour, Mallett & Gucciardi, 2010). Several qualitative studies suggested that mental toughness allows athletes to perform consistently, be unaffected by adversity, thrive under pressure, relish challenges, and possessed an unshakeable belief in their ability to succeed. However, these definitions were extracted from qualitative accounts of mental toughness that included size limited samples, and there were several differences in methodological approach, population choice (specific sports: Gucciardi, et al., 2008, general sports: Golby & Sheard, 2004 and a wider general public: Clough, et al., 2002). For example, studies have utilised the ‘top performers’ in a particular sport, or Olympic champions (Jones, Hanton & Connaughton, 2007). The risk of restricting understanding of mental toughness to a small proportion of the sporting world is evident. It presents an exclusive definition rather than an inclusive conceptualisation, i.e., researchers had thus far only gained an insight into the mental toughness of elite performers, and hence sports people competing at other tiers, or aiming to maximise their potential through effective mental toughness development, were under researched.

This thesis aimed to undertake an holistic examination of the construct of mental toughness, including consideration of the various cognitive, affective, physiological and

behavioural (performance) manifestations of the construct. The data presented here aimed to provide a basis for future research to examine the construct and therefore recover from the narrow research focus (Crust, 2007) that has plagued this field over the last two decades. In doing this, it is hoped that future research will advance in several areas, with a greater emphasis on utilising nomothetic and idiographic research, to establish a clear understanding of this important construct. In order to achieve this aim, several clear objectives were outlined:

- 1) Identify key positive psychological correlates in order to place mental toughness in a framework of existing psychological knowledge, and therefore explore the construct validity of the SMTQ and PPI-A.
- 2) Investigate the biological underpinning of mental toughness through examining the association between prenatal testosterone (previously shown to be important in relation to sporting performance; Manning, 2002) and the construct.
- 3) Explore the physiological indices that relate with mental toughness in an ecologically valid environment, in order to develop alternative objective markers of the construct and extend research understanding of the important physiological differences (Study II).
- 4) Identify cognitive variations in relation to mental toughness, utilising a reputable cognitive self-structure model (Studies III and IV) and determine the discriminatory power of the SMTQ and PPI-A.
- 5) Explore the potential negative side of mental toughness through a case example approach (presenting a theoretically balanced perspective of the construct rather than a predominantly positive viewpoint. Study IV).

6) To utilise the SMTQ and PPI-A in practice and examine the effect of a psychological intervention on an individual's levels of mental toughness (therefore identifying the changeability of mental toughness).

These objectives collectively resulted in an holistic representation and examination of the construct of mental toughness. Importantly, the thesis significantly advanced our understanding of mental toughness and uncovers several fruitful lines for future research. It utilised varying methodologies (qualitative and quantitative) with large cohorts of sports performers, to single case studies. Hence, mental toughness was examined using several methods and from a range of perspectives. This will ensure that the conclusions presented here are not merely an artifact of a particular methodology or approach, and are in fact true representations of the construct. The subsequent conclusions presented here identify important directions for future research and provide initial quantitative evidence for the qualitatively generated claims in current definitions, i.e., mental toughness is arguably a positive psychological variable, in that it relates to success and has properties that are beneficial for performance (Sheard & Golby, 2006; Sheard, 2008) and it relates to physiological, cognitive and behavioural differences (Gucciardi, et al., 2008). Overall, the data provided in this thesis presented empirical support for the previously tenuous claims that had been generated through qualitative research investigations. Therefore, the research studies in this thesis significantly advance our understanding of mental toughness from a holistic perspective, i.e., it considered the development debate of nature versus nurture, along with physiological, cognitive and affective components of the construct. There has been recent criticism that mental toughness is becoming an 'elitist ideal', which is neither an accurate nor desirable grounding for this important construct. Study IV implies there may be negative aspects to mental toughness that have not yet attracted research interest. This thesis

strongly indicates that mental toughness research in populations other than specific groups or levels of achievement should be the way forward.

The primary aims of the individual studies are restated in the table below, along with the sampling technique, measurements used and their contribution to mental toughness research:

	Aims	Participants	Contribution to biopsychosocial model/mental toughness understanding	Measurements
STUDY I	<ul style="list-style-type: none"> Establish the association between biological factors (i.e. prenatal testosterone/2D:4D) and mental toughness. Examine the relationships between mental toughness, positive psychological attributes and performance. 	<p>Heterogeneous sample.</p> <p>121 sport performers from a variety of sports and different competitive levels.</p>	<p>Biological factors contribute towards the psychological development of mental toughness. Mental toughness is significantly positively correlated with optimism, task and ego goal orientations (Nicholls, et al., 2008) and significantly negatively associated with hostility. Mental toughness was also significantly higher in those performers at the top levels of competitive sport (Golby & Sheard, 2004).</p>	<p>Supports the discriminatory power: The SMTQ and PPI-A to discriminate across levels of sporting achievement and a biological measure (2D:4D).</p>
STUDY II	<ul style="list-style-type: none"> Establish the association between physiological and psychological factors and their effect on swimming performance. 	<p>42 national competitive adolescent swimmers of mixed gender.</p>	<p>Provided support for a significant physiological correlate of mental toughness and supported the previously tenuous claim that mental toughness incorporates physiological factors (Gucciardi, et al.,</p>	<p>In order to assess individual characteristics that are not explicitly measured by the</p>

			2008).	SMTQ and PPI-A, credible and existing measures were used, e.g., CSA-2.
STUDY III	<ul style="list-style-type: none"> Investigate the cognitive-affective underpinning of mental toughness. 	<p>Heterogeneous sample.</p> <p>109 sports performers from a variety of sports and at various competitive standards.</p>	Supported the cognitive-affective indices of the self that are associated with mental toughness. Provided support for the notion that mental toughness includes various cognitive factors (Gucciardi, et al., 2008).	<p>Discriminatory power: The SMTQ and PPI-A discriminate between individuals across different sporting achievement levels.</p> <p>Construct validity: Scores on valid self structure model were able to predict scores on the SMQ and PPI-A.</p>

STUDY IV	<ul style="list-style-type: none"> To explore the potential negative aspect of mental toughness manifestation in an athlete during a period of injury. 	<p>Single case participant.</p> <p>19 year old pre-elite, youth, track athlete during a period of chronic injury.</p>	<p>An uneven profile of mental toughness (high scores in determination and commitment and lower scores in control and confidence) could lead to adverse outcomes such as sustained injuries.</p>	<p>A novel examination of the negative aspect of mental toughness manifestation and a more balanced perspective of the construct.</p>
STUDY V	<ul style="list-style-type: none"> To establish the effectiveness of a psychological skill intervention in increasing levels of mental toughness in a novel context. 	<p>Single case participant.</p> <p>41 year old FA football official.</p>	<p>Support was provided for the tentative proposal that mental toughness is important for successful performance in match officials and levels of the construct can be increased via psychological skill training (Sheard & Golby, 2007).</p>	<p>Application of the SMTQ and PPI-A in applied research and practice.</p>

It is widely accepted that mental toughness allows athletes to perform consistently, be unaffected by adversity, thrive under pressure, relish challenges and possess an unshakeable belief in their ability to succeed. However, the definitions were extracted from qualitative accounts of mental toughness from different populations e.g., cricketers (Bull, et al., 2005), footballers (Thelwell, et al., 2006) or Olympic champions (Jones, et al., 2007). Some credibility of the three definitions was provided, as similarities between each conceptualisation were apparent, despite the differences in sample selection criteria and sporting backgrounds. However, on close inspection, subtle differences across each definition emerged. Although further qualitative research may be useful to support or refute the existing conceptualisations of mental toughness, quantitative research that produces findings that can be more confidently generalised, would complement the current understanding. For example, if the existing mental toughness models relate to various physiological and cognitive differences (as suggested by Gucciardi, et al., 2008), this adds credibility to the definitions and corresponding measures that aim to tap into such qualities.

The definitional evaluation provided in Chapter I highlighted the remaining disagreements and the studies presented in this thesis were designed to attenuate such disagreements, through utilising a quantitative approach. Moreover, a sampling bias was evident within the literature; this was suggested to be influenced by an epistemological emphasis upon the ‘elitist ideal’ spectrum of the construct, i.e., mental toughness has been predominantly assessed in the context of excellence and ultimate success, and success and mental toughness have been discussed synonymously. This has resulted in studies which included only the very ‘top performers’ in a particular sport or Olympic champions (Jones, et al., 2007). The inherent criticism of this approach was discussed in Chapter I. It presents an exclusive definition rather than an inclusive conceptualisation, i.e., researchers have thus far

only gained an insight into the mental toughness of elite performers, and hence sports people competing at other tiers may perceive the construct to be unachievable; it is also premature to apply this understanding to lower level performers at this stage in research.

Indeed, following a review of the extant literature, it was apparent that the current proposed conceptual models (Bull, et al., 2005; Gucciardi, et al., 2008; Thelwell, et al., 2006; Sheard, et al., 2006) had been cross validated across several studies that utilised different populations. Although further qualitative research may be necessary to extend this cross validation, the sparse quantitative research was a clear omission in this area. Such research could be beneficial, for example, to support or refute the current conceptualisations of mental toughness, which has been suggested to include various physiological and cognitive differences (as suggested in the definition provided by Gucciardi, et. al., 2008). Moreover, this would provide support for the psychometric properties of the mental toughness measures, specifically examining their discriminatory power and construct validity.

This chapter will revisit each individual objective that collectively formulated the overall aim of the thesis and outline the contribution of each individual study to the understanding of mental toughness. Important avenues for future research are provided along with important theoretical, empirical and applied consideration, followed by an acknowledgement of the limitations of each study.

8.2. BIOLOGICAL MARKER OF MENTAL TOUGHNESS

The existence of individual differences in levels of mental toughness suggests that both biological, predetermined variations and environmental influences are important in the development and manifestation of this psychological construct. One approach in developing

objective mental toughness markers is to examine predetermined, biological factors and their relationship this construct.

Study I located significant associations between 2D:4D ratio, (an indicative marker of prenatal testosterone levels) mental toughness variables, optimism, goal orientations (task and ego) and problem focused coping strategies. The 2D:4D ratio is a sexually dimorphic trait and has been utilised in research that attempts to understand adult physiological and psychological differences that are salient for sport performance. Physiological prowess is indicative of those with low 2D:4D ratio (such as cardiovascular performance), suggesting that prenatal testosterone has a permanent masculinising influence upon adult physical functioning. Study I was the first examination of the permanent influence of this particular androgen upon psychological functioning. 2D:4D was shown to relate to every aspect of mental toughness (across its multidimensional qualities) including self-belief, determination, visualisation and positive cognition (as measured by the PPI-A) along with confidence, constancy and control (as determined via the SMTQ). The 2D:4D ratio was also negatively associated with optimism levels, ego and task goal orientations and positively related to hostility levels. These results tentatively suggest that both levels of mental toughness and other key positive psychological correlates are influenced by prenatal testosterone exposure and are therefore partially predetermined prior to birth. Such a proposal builds on previous research that highlighted the potential genetic contribution to the development of mental toughness. Horsburgh, et al., (2008) identified the variation in levels of mental toughness that could be explained by shared and non-shared environmental influences. Their behavioural genetic examination of 219 pairs of monozygotic and dizygotic twins found that monozygotic twins shared significantly more variance in mental toughness than did dizygotic twins, hence implying that the development of mental toughness was partially due to genetic factors. The

authors also reported that non-shared environmental factors were also responsible for levels of mental toughness. Therefore, the data presented in Chapter III (Study I) extended this line of research and provided exploratory evidence for the contribution of prenatal hormones (specifically testosterone) to adult levels of mental toughness.

Another future advancement that could stem from this kind of research is the development of more objective markers of mental toughness. However, this research must be handled with particular caution. The ethical concerns that arise when considering talent selection or identification of psychological skills from a single physical difference are important considerations. But, the development of more objective markers of mental toughness will help to add weight to the currently criticised psychometric indices of the construct. Furthermore, if important prenatal influences are found to significantly relate to the measurement of mental toughness (SMTQ and PPI-A) it suggests that mental toughness (as defined by these measures) is a valid and important construct in the sporting arena. This research helps to alleviate concerns raised by researchers that criticise current definitions and argue that mental toughness may not exist as a separate and distinct entity, but rather is a combination of other psychological constructs such as self-confidence. Further research of this nature will aid in supporting the distinct and unique conceptualisation of mental toughness.

8.2.1. Limitations and future research

Study I therefore provided initial evidence for the biological perspective, specifically that mental toughness may be partially predetermined in the womb, prior to any environmental exposure. Future research may wish to consider this ratio (2D:4D) alongside the shared genetic element of mental toughness (initially evidenced by Horsburgh, et al., 2009). However it must be noted that the study is cross-sectional in nature and therefore it

must be considered that the results may be due to a remarkable coincidence. Moreover, self-report measures are not the most valid measures of psychological constructs, but further refinement of mental toughness instruments through this kind of research is beneficial for the development of measurements. Future research might also wish to conduct longitudinal studies (that perhaps track mental toughness and performance across a season) in order to confirm the stability of the proposed relationships. Future research might also assess the interactive effect between biological (such as prenatal testosterone) and environmental factors upon the development of mental toughness, as the two aspects have been examined in isolation, despite the probable and potential interactive association between the two. Future research may wish also to address such questions: Are there many different paths to becoming mentally tough? Or is there one optimum route to ultimate mental toughness? Thus, do prenatal influences interact and therefore express through environmental experiences or triggers, and then lead to the development of a certain level of toughness? A further objective of the present thesis was to extend the literature that examined the correlates of mental toughness.

8.3. KEY CORRELATES OF MENTAL TOUGHNESS: AN APPROPRIATE THEORETICAL FRAMEWORK

It is important to understand the correlates of mental toughness for both theoretical and applied reasons. Firstly, it could aid in placing mental toughness in an appropriate conceptual and nomological framework. Thus, gathering such data will aid in producing a comprehensive and data driven model, to support the previously generated subjective, qualitative accounts of the construct. One part of this research quest was to establish the association between mental toughness and other relevant psychological measures. This was important, as psychological constructs are multifaceted and rarely operate in isolation; they

are often either orthogonal or related to other psychological constructs. Such research aided in advancing our theoretical understanding of mental toughness and its location in the broader understanding of psychological functioning. Moreover, identifying key correlates will provide evidence for the inclusion of specific strategies in psychological skill training (Nicholls, et al., 2008).

For example, other researchers, i.e., Nicholls, et al., (2008), support the use of optimism skill training in an attempt to increase mental toughness, as their study highlighted an association between these two variables. The findings in this thesis support and extend this notion. Sport performers who reported high levels of mental toughness (as measured by the SMTQ and PPI-A) also scored higher in terms of optimism, problem focused coping, ego and task orientations and reported lower levels of hostility. Therefore, it appears that encouraging a balance of motivation orientations (encouraging both self-comparison task orientated and competitive goals: ego orientated) may lead to increased levels of mental toughness. Further research may wish to examine the effectiveness of these particular training methods using randomised control trials. Moreover, the finding that hostility is low in those with high levels of mental toughness is a novel and intriguing one. Perhaps those with increased mental toughness are secure, confident and outgoing, and are therefore able to form trusting, close relationships? Thus, such individuals might be less likely to develop a level of suspicion or hostility. Such a proposal supports Clough, et al.,’s (2002) definition: “*mentally tough individuals tend to be sociable and outgoing.*”

Mentally tough individuals generally have more optimistic views regarding their future and potential outcomes. Such a finding supports the assertions of previous qualitative research that suggests such individuals have a high sense of self-belief and internal locus of control, along with a sustained and maintained determination to achieve their life goals.

Hence, it would appear logical that these individuals perceive that they possess all of the necessary skills and qualities to achieve, and feel they have a central and instrumental influence over their future achievements and behaviours. It is typical that those with internalised motives and perceptions of control are likely to be more optimistic about their future, given that they are the central instigator of their life outcomes, rather than perceiving their life as determined by external sources.

8.3.1. Future research and limitations

Perhaps future research may wish to extend such findings, as they are limited, in that they are drawn from a cross-sectional study; inferences about the stability of these associations are obviously impossible. Further longitudinal research that attempts to track these associations over a longer period of time, perhaps a sporting season, would be useful in advancing understanding to this end. Moreover, the use of experimental methods will allow researchers to establish relevant behavioural correlates. Studies that manipulate an aspect of the environment in controlled settings and assess the influence of different situations upon behavioural correlates and their interaction with mental toughness could further advance understanding on this topic.

8.4. PHYSIOLOGICAL CORRELATES OF MENTAL TOUGHNESS

A recent meta-analysis of experimental studies showed that social-evaluative threat during task performance and low control over the situation were the two best predictors of acute cortisol responses in humans (Dickerson & Kemeny, 2004). Such characteristics have been reported in mental toughness definitional studies (Gucciardi, 2012; Sheard, 2008).

Physical stressors such as intense exercise also activate the HPA axis. The observation that cortisol elevations are often greater during competitive sports than during training at the same

level of physical exertion (Cook, Read, Harris, & Riad-Fahmy, 1987) indicates that physical and psychosocial components of competition might have additive effects. Therefore, cortisol is one biological marker of stress and therefore could provide an objective indication of perceived threat prior to and during a competitive event. Study II attempted to examine the association between mental toughness and this indication of perceived threat or stress during a real competitive event.

This study, which included a relatively large sample ($n=42$) in comparison with other studies involving hormones, reported significant associations between characteristics of mental toughness and total cortisol output. Its findings located significant associations between characteristics of mental toughness and actual performance in a typical competitive swimming event. However, contrary to some previous research findings (Fillaire, et al., 2007) cognitive and somatic anxiety interpretations did not significantly correlate with total cortisol output. One strength of Study II was that it also assessed the recovery period immediately following competition (rather than just anticipatory responses) and therefore may have tapped into appraisals of performance following the swim event (research has shown that external or internal attributions following performance influence cortisol concentrations). Mental toughness is suggested to be related to resilience and ‘insensitivity to the negative cognitions following poor performances or criticism’ (Bull, et al., 2005; Clough, et al., 2002). Hence, it appears logical that such individuals secrete lower levels of a hormone that signals poor adjustment or negative appraisals following a stressful event.

Previous research had also highlighted a linear relationship between resilience and cortisol secretion (Haglund, et al., 2007) whereas, the present findings suggest that their association may be rather more interactive and complicated. Specifically, those with the highest self-reported levels of resilience and lowest slightly acute cortisol response were the

most successful performers, whereas, swimmers who reported high resilience, but also secreted high cortisol levels, performed worse, followed by those with low resilience and low cortisol levels, and the poorest performers were those with low resilience scores and high cortisol levels. The results of Study II suggest that this insensitivity to competition stress (resilience) reduces the negative impact of physiological stress arousal (activation of the HPA axis) upon performance. Hence, those with higher resilience, yet relatively high cortisol levels, are able to perform better than those with lower scores on resilience scales.

8.4.1. Future research and limitations

The limitations of Study II include the cross-sectional design and the limited physiological measurements. Indeed, cortisol has been shown to be indicative of perceived stress levels, but hormones rarely operate in isolation. Research has also included measurements of the T (testosterone) C (cortisol) ratio and has found associations with this ratio and performance. Perhaps future research may wish to examine the interactive influence of a combination of hormones upon performance, and explore their association with mental toughness.

As previously noted, the existing qualitative research has suggested that mental toughness incorporates cognitive factors. A thorough understanding of these factors is perhaps necessary in order to understand the importance of mental toughness in sport performance and the various manifestations of the construct.

8.5. COGNITIVE-EFFECTIVE CORRELATES OF MENTAL TOUGHNESS

Developing an understanding of these factors is necessary in order to understand the importance of mental toughness in sport performance and pinpoint the uniqueness of the construct. However, aside from qualitative assertions drawn from coaches and elite athletes

(that have their own limitations, see Chapter I); to date no empirical evidence had supported the existence of the proposed cognitive variables that are associated with mental toughness, aside from the few investigations that examine coping strategies.

Nicholls, et al., (2008) found that mentally tough performers appraise and cope with stress in an adaptive fashion. Study IV extended this research by addressing the cognitive profile of mentally tough performers. These data suggested that mentally tough individuals had an overall positive self-concept and therefore greater levels of self-esteem and confidence. Furthermore, those with integrative self structures (the inclusion of both positive and negative self-beliefs in each cognitive role or self-aspect) generally demonstrated greater levels of mental toughness. This finding was anticipated, given that the literature on *compartmentalisation* had suggested that integrative thinkers have a less reactive cognitive-affective core (and therefore may respond with less extreme emotion to stressful events) and are more rational thinkers. This obvious parallel with mental toughness (they are logical and rational thinkers) makes sound theoretical sense.

Moreover, the data provided evidence that elite athletes self-report higher levels of mental toughness (SMTQ) than individuals who participated in lower levels of competition, and that these scales are associated with a measure of self-concept with a strong empirical history of predicting emotion and self-esteem. Further findings concluded that, across SMTQ measures, the proportion of negative self-content was associated negatively with mental toughness (control, confidence), and was qualified by an interaction with evaluative self-structure for the subscale of constancy. Overall, people with positively integrative self-structures reported highest scores on the SMTQ. Compartmentalisation, regardless of negative content, tended to indicate more moderate levels of mental toughness, in comparison with integration. Lastly, in support of previous research (Golby & Sheard, 2004; Kuan &

Roy, 2007), greater self-reported mental toughness was found in individuals at the highest level of sporting achievement, wherein national and international competitors reported the highest levels of mental toughness (viz., confidence and control subscales). The study provided initial evidence for the theoretical association between mental toughness and self-structure and suggests that mental toughness manifests in the cognitive structure of the self.

The finding that positive integratives have especially high levels of mental toughness is consistent with previous research linking this structure with levels of resilience (cf. Showers, 2002). For example, positive-integratives arguably reduce the negative impact of self-doubt by activating positive self-qualities (“*I am capable*”) that maintain or increase confidence. Indeed, Ditzfeld and Showers (in press) report that positive integratives perceive their multiple selves as more authentic (i.e., self-determined; cf. Ryan & Deci, 2000), and have lower self-worth contingencies (cf., Crocker & Wolfe, 2001), than people with other self-structures. Taken together, positive-integratives seem to remain calm in the face of challenges, perhaps because their self-esteem is not contingent on performance (e.g., Zeigler-Hill & Showers, 2007) whereas positive-integration corresponds with high levels of mental toughness; integration when one’s self-concept is relatively negative appears to demonstrate the opposite effect. Showers, Zeigler-Hill & Limke (2006) suggest that negative-integratives fail to buffer against the impact of their negative self-beliefs, which creates increased stress, negative mood, and lower self-esteem. By definition, these individuals should possess low levels of mental toughness.

Over most levels of sports competition, positive-integration may facilitate superior performance, with the exception of international athletes. These sport performers were disproportionately more compartmentalised than people in lower levels of competition. In elite athletes, compartmentalisation may hold an advantage, because these individuals’

extreme affective reactivity (Ditzfeld & Showers, in press) may place them “in the zone” (e.g., social facilitation; cf., Zajonc, 1965) and more likely to experience the phenomenon of ‘flow’. Hence, compartmentalisers may not be particularly mentally tough (in fact, they may respond to losing with extreme negative affect), but their superior athletic ability may come to the surface in pressured situations. Precaution should be taken before making strong inferences, however, because of the small number of international competitors represented in that sample. Overall, positive integration appears advantageous in sport for most individuals, because occasional failures seem inevitable across most levels of competition, whereas, compartmentalisation may benefit those whose successes far outweigh their failures.

The novel application of this model and the interdisciplinary nature of this research highlighted the need for researchers into mental toughness to consider psychology research in total, rather than taking a restricted focus on sport psychology domain research alone. It also helps to understand the apparent ‘emotional stability’ of mentally tough individuals, which previous researchers had suggested may be caused by a reduced intensity of affect response to stressors (Crust, 2008) but have found no significant results. Perhaps a crucial cognitive difference or unique attribute of mentally tough athletes is their ability to structure their self in an integrative fashion; particularly in times of stress and adversity (this structure is protective of self-esteem when life is very challenging). Study IV provided initial evidence for this proposition and the utility of a model of the self in understanding the cognitive manifestations of mental toughness.

8.5.1. Future research and limitations

Several limitations of Study IV must be noted when considering the findings. Firstly, self-structure is a dynamic process that alters in response to external stressors and demands and therefore cross-sectional studies give a limited snapshot perspective of the individual’s

self-concept. Perhaps future research may wish to assess changes in self-structure and the intensity or appraisal of stress, along with details of personal circumstance at the time of measurement. Perhaps mentally tough individuals are able to adjust dynamically and effectively to periods of stress or negative affect in individual roles, by shifting their perceptions of importance, in order to protect self-esteem and remain emotionally stable. Many early studies reported that athletes view emotional stability and reduced negative affect as central attributes of mental toughness. There are likely to be cognitive-affective and biological factors that play a role in emotional stability; therefore research should seek to provide evidence for important cognitive-affective factors.

8.6. UTILISING PHYSIOLOGICAL, COGNITIVE AND BEHAVIOURAL MARKERS OF MENTAL TOUGHNESS IN APPLIED PRACTICE

It is useful to develop various markers of psychological constructs in order to pinpoint the different levels of manifestation of mental toughness and support the convergent validity of this construct. Indeed, if mental toughness can be measured utilizing various techniques that target different levels of human functioning (e.g., physiological and cognitive) then it is likely that mental toughness exist as a separate construct. Moreover, if these proposed markers are found to be associated with more successful performance (e.g., study I, II and III) then it provides support for the claim that mental toughness is a desirable trait and is associated with better performance outcomes.

An anecdotal example of a contemporary sporting hero highlights the difference between a successful and happy athlete and a successful yet troubled athlete who lacks psychological wellbeing. Dame Kelly Holmes had a career plagued with injury, after her initial taste of success in the Atlanta Olympic games. Following this she suffered ten years of repetitive stress injuries that resulted in her hopes of Olympic gold being thwarted. Kelly

Holmes now openly speaks of her turbulent career, explaining how she suffered from deep depression and anxiety and engaged in repeated self-harm. She claims that her desire to succeed was so strong and she felt she was doing everything within her control, i.e., train hard and rebound from failure by returning to training and competition at the earliest stage (although her beliefs were maladaptive, as she attributed success to gritty determination and strong work ethic). It would appear that the majority of mental toughness research may select Kelly Holmes as a sport performer who was mentally tough.

However, if we do suggest Ms Holmes is mentally tough, what are the problems associated with suggesting mental toughness is a desirable trait, or an 'elitist ideal', yet those sport performers on whom we base our understanding are potentially mentally flawed (they may achieve great heights yet have negative psychological wellbeing). If this is an accurate definition of mental toughness, there needs to be some acknowledgement of the downside to mental toughness and an alternative approach to placing mental toughness in the positive psychological paradigm (the approach suggested by Sheard, 2008). On the other hand, if mental toughness is related to positive psychological characteristics e.g., optimism, happiness and low incidence of mental health problems (Nicholls, et al., 2008; Clough, et al., 2002), then are we really selecting appropriate samples? It seems almost illogical to have a sample selection criteria that is based on no empirical evidence; surely a more appropriate approach at an early stage in research would be to study an eclectic and varied population, in order to understand the full range of mental toughness. More experimental methods that measure individuals in a variety of situations may be useful, e.g., do they conform to common group perceptions and norms less readily than others with lower mental toughness (sometimes termed stubborn mindedness) and are they possibly less receptive to opposing views or perspectives that challenge their current predisposition? Experimental methods such as those

used in social psychology (research into conformity) would be a useful method of examining such research questions. Furthermore, greater empirical support can be attributed to understanding of mental toughness if more objective experimental methods are utilised.

8.7. THE SMTQ AND PPI-A

The data in Study III demonstrated that the SMTQ global score is a good predictor of levels of sporting success, despite low-to-moderate correlations among its subscales ($.15 \geq r_s \leq .35$). It appeared that (in Study III); only a relatively small group of people maintain high levels of control, constancy, and confidence. Importantly, these individuals tend to be linked by a common cognitive self-structure, i.e., positive integration. Results from Study III suggest that although possessing all three characteristics aids sporting success, scoring low on one or two of the subscales does not necessarily preclude good performance. The results suggest that performers may have high confidence, yet low constancy, and still be mentally tough enough to succeed.

In Study 1 it was noted that those who reported the highest scores on the SMTQ and PPI-A were also the top performers, i.e., performing at the highest echelons of sporting competition. Hence, it appears that the SMTQ and PPI-A are capable of discriminating individuals based on levels of achievement. In summary, this study provided initial evidence for the SMTQ's and PPI-A's discriminatory power or discriminant validity (it is able to discriminate between different levels of performers). Moreover, support was provided for the SMTQ's construct validity, as it has been shown to be significantly associated with a well-established measure of self-concept that has previously been shown to differentiate emotional categorisation and esteem.

The SMTQ has received mixed attention, initial support for its internal consistency, internal validity and retest reliability is reported in the literature (Crust & Swann, 2011). However, the measure has also been subject to criticism regarding its factor structure (the SMTQ measures the elements of self-belief, determination, positive cognition and visualisation). Therefore, rather than abandoning the SMTQ as an appropriate, reliable and valid measure of mental toughness, perhaps future research may wish to continue to validate the measure and refine selected items that are particularly tentative. Retaining and refining would be valuable, as it is one of few applied measures that are appropriate for use across all sports, rather than a specific sport, such as cricket or football. Moreover, the measure has a manageable 14 items, in comparison with more lengthy and less practically appropriate instruments. This is especially useful in the sporting environment, as completing a lengthy assessment prior to competition would be logistically difficult, if not impossible.

The studies presented in this thesis were designed to significantly advance our understanding of mental toughness. It appears that mental toughness manifests in the form of cognitive, physiological and behavioural variables that are related to themselves and to performance. Specifically, those with higher scores on measures respond to competition with a reduced physiological stress response and an individual's level of mental toughness interacts with their level of cortisol to influence performance, i.e., those with increased resilience to negative events, yet a relatively high physiological response to competition, are able to perform better than those who are less resilient. Such research demonstrates the inter-related and complex influence of physiological responses to competition and the stress buffering construct of mental toughness (namely the resilience aspect of this multidimensional construct) upon performance.

Intuitively, mental toughness should relate to performance, in that individuals with increased levels are able to remain composed and calm in stressful circumstances (competition) and are able to push physical pain barriers to reap the best physical gains in training and competition. Research then began to inductively explore mental toughness and many coaches and performers reported successful and consistent performance as a major attribute of those with high levels of the construct. It is only recently that empirical evidence has been generated to support this claim, including the findings presented in this thesis.

Those assessing achievement related aspects of mental toughness have frequently conducted cross-sectional studies. These studies are useful in early research to highlight exploratory trends in the sporting arena, e.g., Golby & Sheard (2004) found that mental toughness scores could discriminate among achievement levels: international performers reported significantly higher levels than national and regional performers. However, cross sectional research requires replication in different contexts, in order to substantiate the findings. Two studies presented in this thesis extended this area of mental toughness research. They demonstrated that scores on the SMTQ and PPI-A were capable of discriminating among different achievement levels. However, it remains uncertain whether competing in higher levels of sport required and led to the development of mental toughness, or if mental toughness allowed individuals to enter into the highest tiers of competition, as of course causal implications are impossible at this stage. Moreover, in slightly different research, this thesis noted that characteristics of mental toughness (namely resilience and competitive anxiety) are associated with successful performance in an ecologically valid competitive setting. This research utilised more credible and well established psychometric measures from other areas of enquiry, rather than measures that were specifically developed to measure mental toughness (SMTQ and PPI-A). Therefore, two approaches encompass this research,

firstly in extending the use of existing mental toughness measurements, and secondly including more credible and rigorously tested instruments that capture specific aspects of mental toughness. Indeed, when measures with a solid theoretical foundation and demonstrable sound psychometric properties develop, then research can demonstrate conclusions with increased confidence.

8.8.1. Summary and future research

This thesis attempted to provide initial support for the different research approaches that can be utilised when studying and conceptualising a new psychological construct, such as mental toughness. The findings presented here offer a range of perspectives from which to examine mental toughness, including exploring the key correlates associated with the construct (physiological, biological and cognitive affective variables), examining developmental influences, inductive research to explore the potential negative outcomes associated with the construct, and research into psychological skill training research.

Collectively the five individual studies presented have addressed the different physical, physiological and cognitive-affective variables, or differences that are deemed important when considering mental toughness (Gucciardi, 2012). This research quest has also identified potentially useful indices or markers (i.e., cortisol) and cognitive models (self-structural compartmentalisation model). These findings arguably significantly advance the understanding of mental toughness and provide initial empirical support for the generated definitions that currently exist within the extant literature. For example, the SMTQ model provided by Sheard, et al., (2009) receives quantitative support from the findings in two studies (Chapter III and Chapter IV).

There are several avenues for future research might be highlighted by these studies. For example, studies into physiological manifestations of mental toughness could incorporate more complete patterns of hormonal changes across different stressful situations and contexts. It may be useful to study the hormonal changes of individuals in laboratory settings, in order to pinpoint the exact differences in hormonal response with the removal of external influences that are inherent in the sporting environment. Furthermore, including qualitative research would complement the objective hormonal measures and expand on the “how” and “why” individuals respond in different ways.

Since the current study did not explore the transferability of mental toughness from one context (possibly sport) to another (academic/vocational), future research may wish to compare sport performers’ mental toughness and physiological response to stress (competition) in a sporting environment (one in which they are familiar) and then in an unfamiliar context (such as giving a public speech: the TSST is a useful paradigm) in order to assess the transferability of the construct. Several researchers have suggested that mental toughness may be context specific and mental toughness in one area of life does not necessarily transfer to another. The cognitive structure of the self would also be a useful indicator of how the sport performer views life holistically, rather than solely in the sporting domain. Research of this nature is useful, as it considers the sport performer in their entirety, as psychological research suggests that performance in each area of life is interrelated. Perhaps mental toughness and the structure of the self-concept should be examined in terms of wellbeing, rather than merely performance. Arguably, the two primary factors in producing effective athletes is that they are 1) able to succeed and 2) experience positive psychological outcomes from sport, and are able to transfer such skills into other contexts later in life.

Perhaps future research may wish to explore the association between mental toughness and effective transitions in sport, including the critical transitioning periods, for example, progressing from youth to senior level, from national to international level, from Olympic success to Olympic glory (medal winner) and retirement from sport. Furthermore, perhaps meditational analyses would be useful to examine mental toughness as potential mediator of the stress-performance association.

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APPENDIX 1

Examples of Compartmentalised and Integrative Self-Concept Structure

Compartmentalised Structure					
<i>In training</i>	<i>Competition</i>	<i>Friend</i>	<i>Shop assistant</i>	<i>University</i>	<i>Coach</i>
Happy	-Not the “real me”	Capable	-Weary	-Inferior	Organized
Successful	-Lazy	Friendly	-Indecisive	-Isolated	Hardworking
Communicative	-Disorganized	Optimistic	-Isolated	-Immature	Intelligent
Independent	-Indecisive	Interested	-Tense	-Self-Centered	Capable
Optimistic	-Immature	Capable	-Lazy	-Incompetent	Lovable
Outgoing	-Like a failure	Comfortable	-Uncomfortable	-Disorganized	Optimistic
Intelligent	-Tense	Intelligent		-Tense	Interested
Energetic	-Irritable	Mature			Happy
Confident		Fun & Entertaining			Independent

Integrative Structure				
<i>Student</i>	<i>Netballer</i>	<i>In training</i>	<i>Friend</i>	<i>Competition</i>
Organised	Energetic	Energetic	-Irritable	Needed
Hardworking	Lovable	Happy	-Indecisive	Hardworking
Friendly	-Weary	Communicative	-Tense	-Indecisive
-Tense	Insecure	Energetic	Hardworking	Energetic
Successful	Communicative	Friendly	Friendly	-Tense
-Not the “real me”	Careless	Optimistic	Needed	-Immature
	Communicative	Hardworking	Fun & Entertaining	
	Needed	-Weary		
	-Immature			
	-Irritable			
	Happy			
	Comfortable			
	Outgoing			

NB: Examples of actual participants’ compartmentalised ($\phi = 1.0$; differential importance = .76; proportion of negative self-beliefs = .44) and integrative ($\phi = .27$; differential importance = .44; proportion of negative self-beliefs = .35) card sorts.

APPENDIX 2

Exploring the organizational effect of prenatal testosterone upon the sporting brain.

By

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